April 1960

75¢

SEMICONDUCTOR PRODUCTS

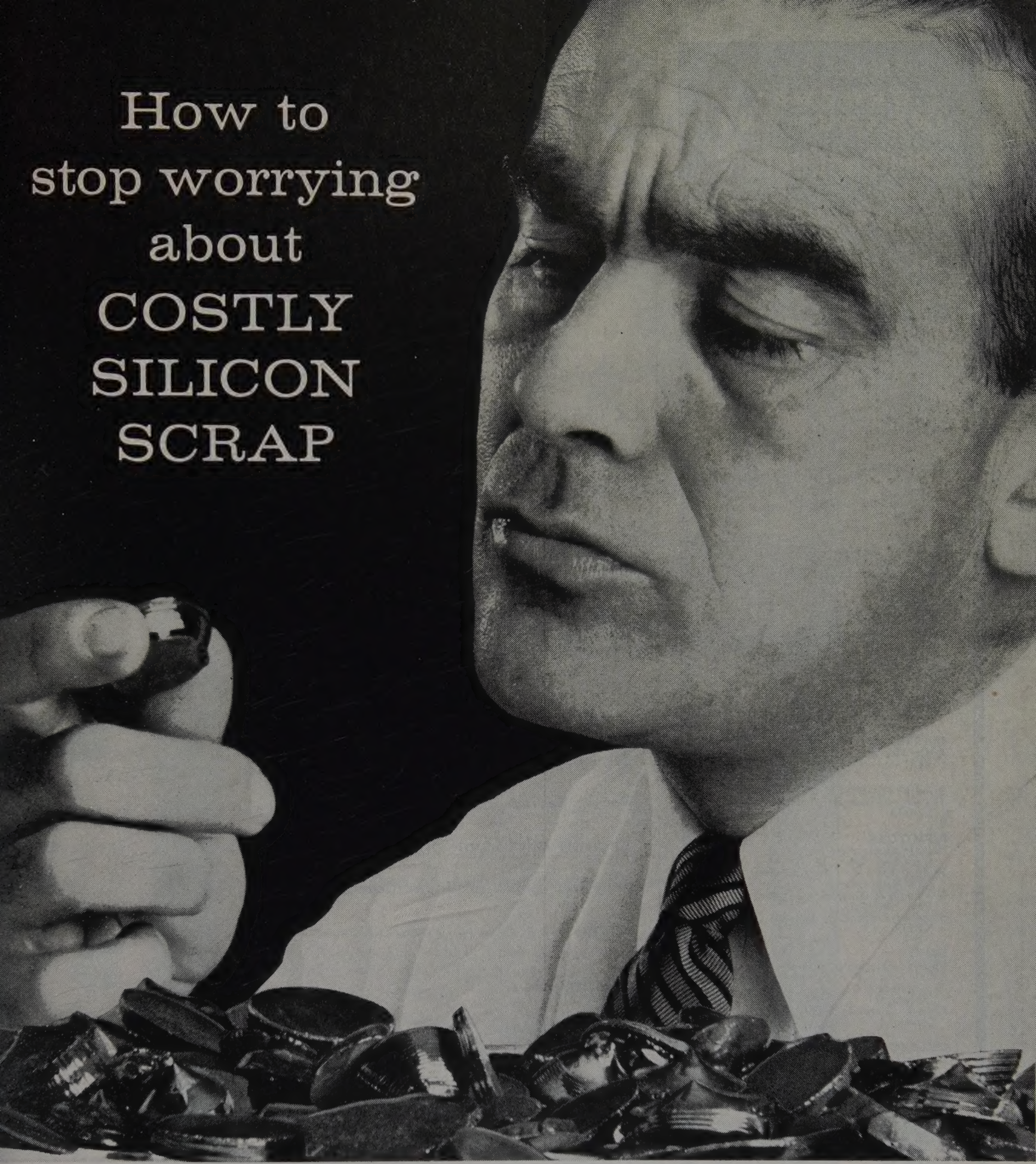
Semiconductor Networks

Commercially Available

Transistor Bidirectional Limiter

Power Inversion Techniques

Junction Transistor Measurements and Standards



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BASE BORON CONTENT BELOW ONE ATOM OF BORON PER SIX BILLION SILICON ATOMS

SEMICONDUCTOR PRODUCTS

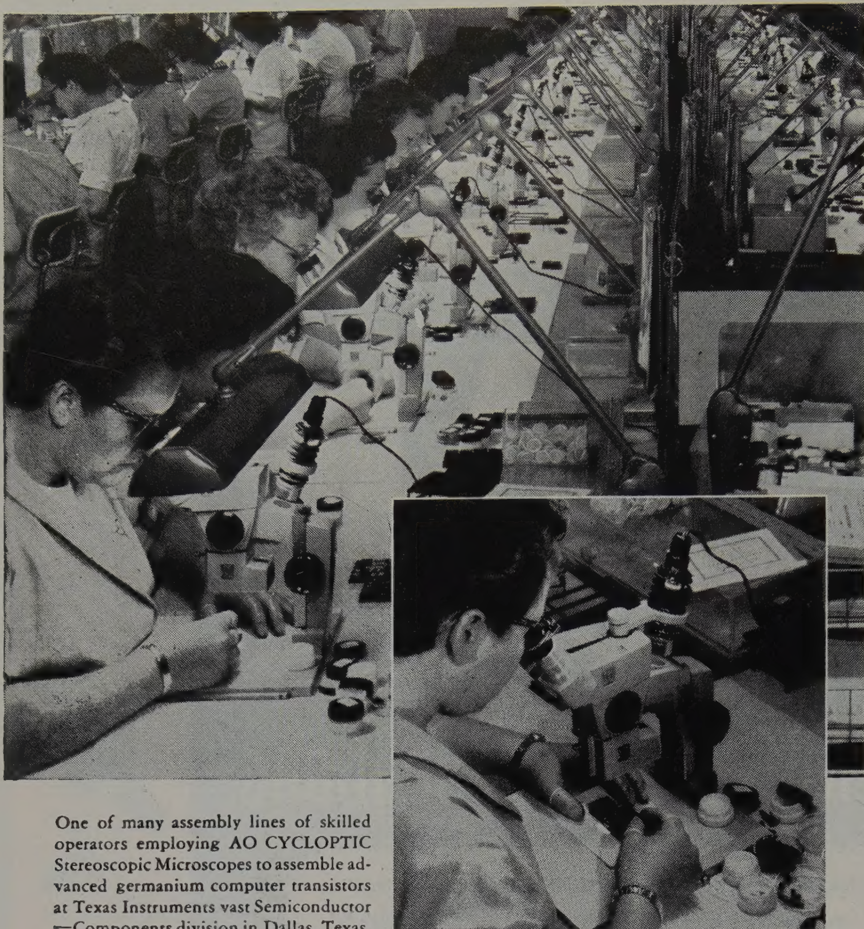
SANFORD R. COWAN, Publisher

April 1960 Vol. 3 No. 4

CONTENTS

Front Cover

Depicts the solid circuit network bonding of leads to the active elements. Solid circuit semiconductor networks are produced by techniques which are logical extensions of mesa production techniques. Diffusion, oxide-masking evaporation, and chemical forming are used to make a single crystal semiconductor wafer perform the function of a complete circuit. Photograph courtesy of Texas Instruments Incorporated.



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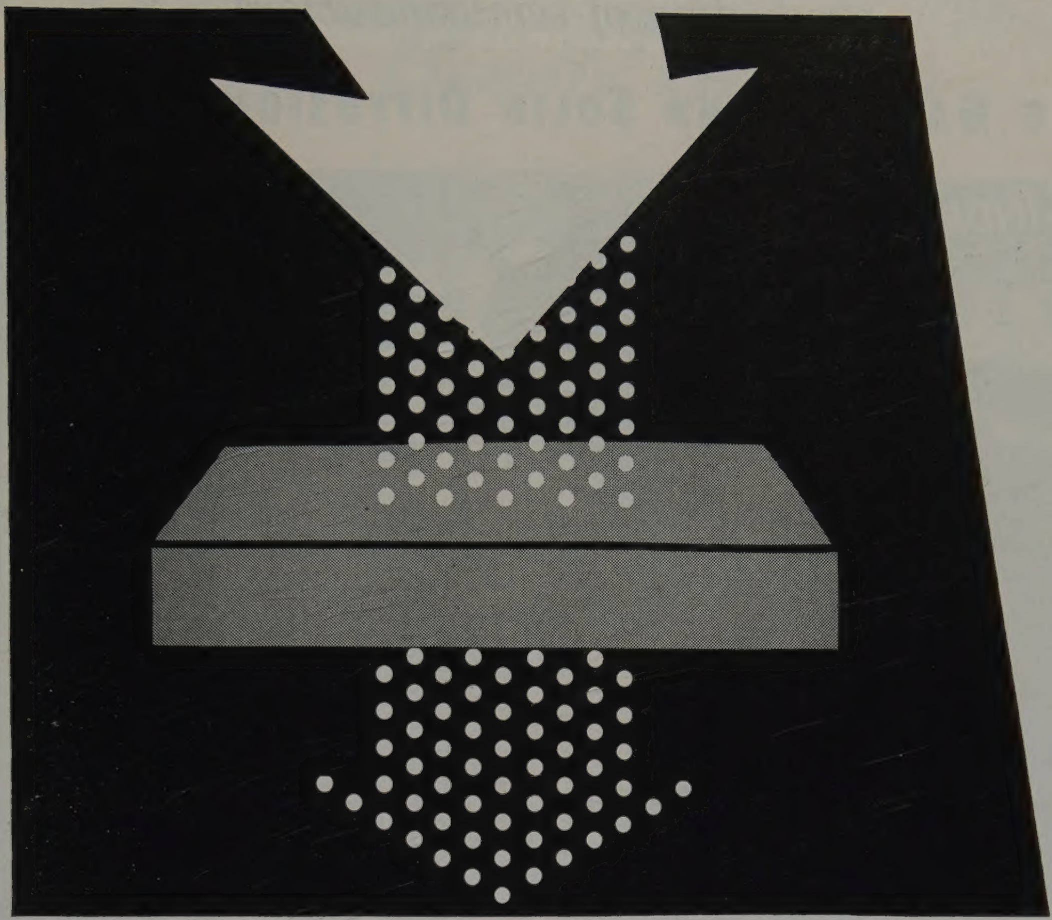
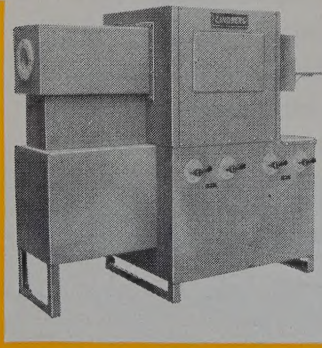


For basic research, pilot plant studies and production of semiconductors

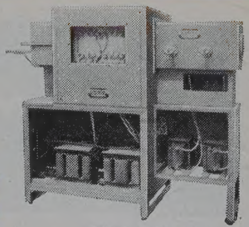
LINDBERG GASEOUS AND SOLID DIFFUSION FURNACES

These Lindberg four-tube furnaces at Microwave Associates, Inc., provide maximum continuous operating temperature to 1371°C. (2500°F.). Chamber accommodates four 2" O.D. and has a uniformity of plus or minus 5.0°C.

Microwave Associates, Inc., Burlington, Mass., a leader in the development of specialized semiconductor products, must give careful consideration to the choice of technical equipment to assure maintaining their position in this highly competitive field. Consequently, the Microwave installation shown above was selected from Lindberg's complete line of gaseous and solid diffusion furnaces for quality transistor and semiconductor devices. This line provides a wide variety of standard sizes and capacities to enable manufacturers in the semiconductor field to have higher powered equipment adequately insulated and designed for its specific use. Models available in single and multiple zone types and a variety of tube sizes up to 4" I.D. These Lindberg furnaces are versatile, perfectly adaptable for basic research, pilot plant study and production.



LINDBERG SOLID DIFFUSION FURNACE: Preheat chamber 21" long with two zones of control—maximum temperature 900°C. (1652°F.). High heat chamber 16" long with two zones of control, maximum operating temperature 1300°C. (2372°F.).



For full information call your local Lindberg Field Representative (see your classified phone book) or write for Bulletin No. 1081.

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EXTRA QUALITY AT NO EXTRA COST WITH BENDIX TRANSISTORS

Bendix Bulletin

Up-to-the-minute news about transistors

NEW DRIVER TRANSISTORS SWEEPING THE FIELD

Extra-versatile Bendix units beat high costs, design limitations over wide front

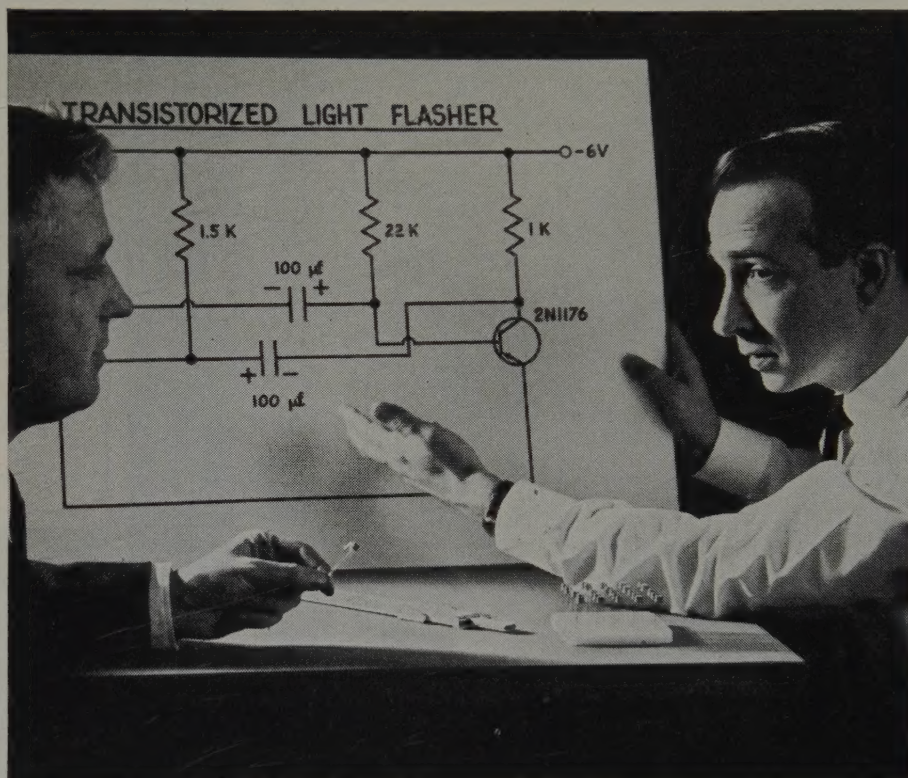
Called the "workhorse of the transistor industry," the new Bendix* Driver Transistor series is winning the nod from more and more engineers daily. These men find it the answer to audio frequency and switching applications requiring extra performance without extra cost.

Here is a special device for use where reliability, versatility, and low cost are primary requirements. The Bendix units combine higher voltage rating and high current gain with more linear current gain characteristics for low distortion and more efficient switching.

They're now in high production for rapid delivery in JEDEC TO-9 packages.

NEW BENDIX SEMICONDUCTOR CATALOG on our complete line of power transistors, power rectifiers, and driver transistors available on request. Write SEMICONDUCTOR PRODUCTS, BENDIX AVIATION CORPORATION, LONG BRANCH, N. J. For information about employment opportunities write personnel manager.

*TRADEMARK



ENGINEERS KNOW the new Bendix Driver Transistor line-up meets an unusually wide range of circuitry applications. Bendix Applications Engineering Department suggestions on circuitry problems are helpful, too.

APPLICATION, PERFORMANCE DATA INDICATE BROAD USAGE

TYPE NUMBERS	MAXIMUM RATINGS					TYPICAL OPERATION		
	Vce Vdc	Ic mAdc	Pc mW	Tj °C	T storage °C	hfe Ic = 10 mAdc	fαb Ic = 10 mAdc	Vce(Sat) Ic = 100 mAdc Ib = 10 mAdc
2N1008	−20	300	400	85	−65 to +85	90	1.2 mc	0.15 Vdc
2N1008A	−40	300	400	85	−65 to +85	90	1.2 mc	0.15 Vdc
2N1008B	−60	300	400	85	−65 to +85	90	1.2 mc	0.15 Vdc
2N1176	−15	300	300	85	−65 to +85	65	1.2 mc	0.15 Vdc
2N1176A	−40	300	300	85	−65 to +85	65	1.2 mc	0.15 Vdc
2N1176B	−60	300	300	85	−65 to +85	65	1.2 mc	0.15 Vdc

Ideal for such applications as:

TRANSISTOR DRIVER • AUDIO AMPLIFIER (CLASS A OR B)
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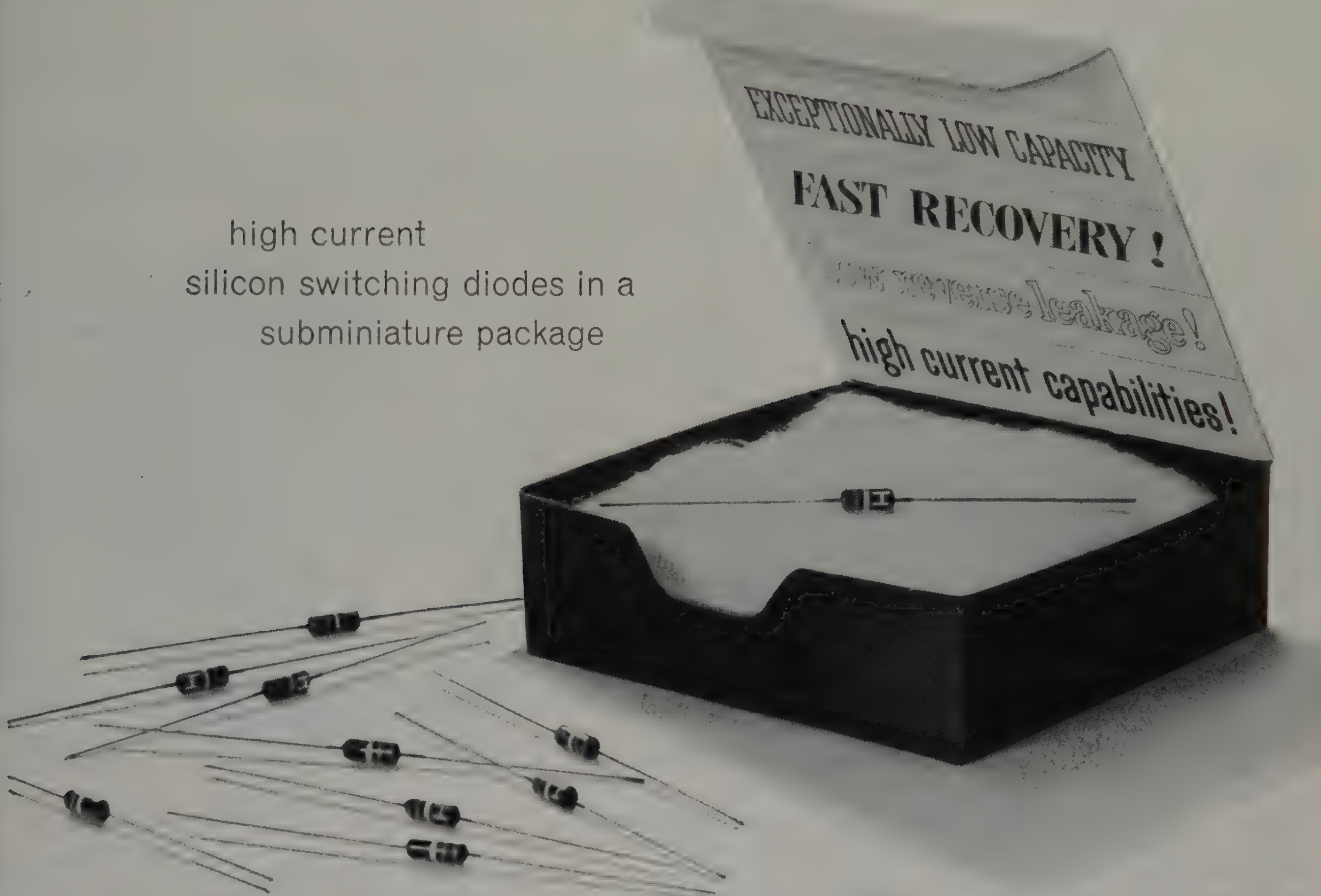
For greater computer design flexibility

high current
silicon switching diodes in a
subminiature package



100 mA Min. @ 1V Forward Current...0.3 μsec recovery...4 μμf at −2V...now HUGHES can offer you these diode characteristics with no sacrifice in package size. Result: greater design flexibility for computer applications! With these characteristics, these diodes will cover practically every major computer switching requirement.

An added feature: the ability of these diodes to handle high current with a fast recovery time makes it possible to use them in many general purpose applications, as well as computers. With their hermetically sealed glass envelopes, these HUGHES® diodes have been engineered for extreme reliability under adverse environmental conditions.

TYPICAL SPECIFICATIONS:

Type	Min. Es (@ 100μA)	Min. Fwd. Current @ 25°C (@ +1.0V)	Max. Reverse Current (μA) @ 25°C	Max. Reverse Current (μA) @ 100°C	Reverse Recovery Rev. Resist. (R) (ohms)	Reverse Recovery Max. Rec. Time (μsec)
1N837	100	150	0.1 @ − 75V	15 @ — 75V	400 K	0.5*
1N838	150	150	0.1 @ —125V	15 @ —125V	400 K	0.5*
1N839	200	150	0.1 @ —175V	15 @ —175V	400 K	0.5*
1N840	50	150	0.1 @ — 40V	15 @ — 40V	400 K	0.3*
1N841	150	150	0.1 @ —120V	15 @ —120V	400 K	0.3*
1N844	100	200	0.1 @ — 80V	15 @ — 80V	400 K	0.5*
			Improved Standards			
1N643A	200	100	.025 @ — 10V	5 @ — 10V	200 K	0.3†
1N662A	100	100	1.0 @ — 10V	20 @ — 10V	100 K	0.5†
1N663A	100	100	0.1 @ — 75V	15 @ — 75V	200 K	0.3†

*Measured in JAN test circuit and switched from 30mA forward current to —35V.
†Measured in JAN test circuit and switched from 5mA forward current to —40V.
Typical capacitance: C_{-10} = 2.2 μμf $C_{-1.5}$ = 4.4 μμf C_{-0} = 9.0 μμf
Operating temperature range: —65°C + 150°C Storage temp. range: —65°C + 200°C

For additional information concerning these unique HUGHES diodes call or write the Hughes sales office or distributor nearest you. Or write Hughes, Semiconductor Division, Marketing Department, Newport Beach, California. ***For export write: Hughes International, Culver City, California.***

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HUGHES

SEMICONDUCTOR DIVISION

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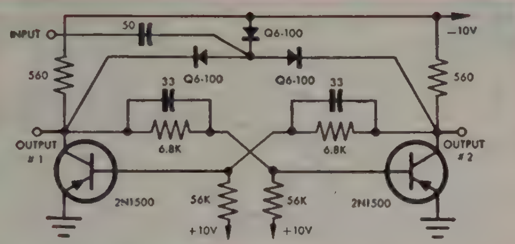
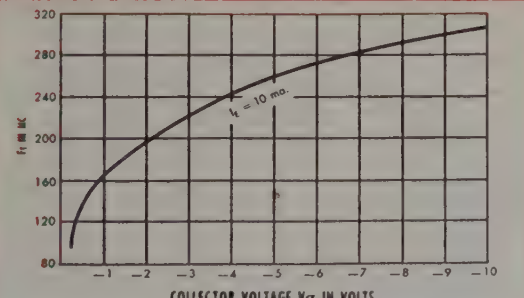
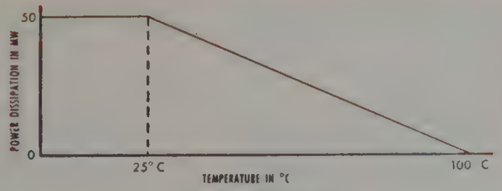


SIMPLE 20MC BINARY STAGE



TYPICAL GAIN-BANDWIDTH PRODUCT, f_T VS. COLLECTOR VOLTAGE



DERATING CURVE

*MADT . . . PHILCO REGISTERED TRADEMARK for Micro Alloy Diffused-base Transistor.

New MADT* 2N1500 Provides Increased Power Dissipation

Here is another Philco "break-through" in the design and manufacture of high frequency, ultra high-speed switching transistors! This new Micro Alloy Diffused-base Transistor (MADT*) uses cadmium electrodes in place of indium. The higher thermal conductivity of cadmium insures cooler-running junctions for any given power dissipation and provides an extra margin of safety as added assurance of reliable performance.

The new 2N1500 offers the designer these important advantages:

- 100° C maximum junction temperature
- low collector capacitance
- high Beta and excellent Beta linearity with temperature and current
- low hold storage time (Typical: 7 mμsec)
- low saturation voltage

In electrical characteristics, the 2N1500 is similar to 2N501, which has been thoroughly field-proven in many military and industrial computer applications. It is manufactured on Philco's exclusive fully-automated production lines to the highest standards of uniformity. For complete specifications and applications data, write Dept. **SC-460.**

Max. Ratings		Typical Parameters				
T_{STG} °C	V_{CB} volts	t_r mμsec	t_s mμsec	t_f mμsec	h_{FE}	V_{CE}(SAT) volts
100	−15	12	7	4	35	−0.1

AVAILABLE IN PRODUCTION QUANTITIES . . . and in quantities 1-99 from your Philco Industrial Semiconductor Distributor.

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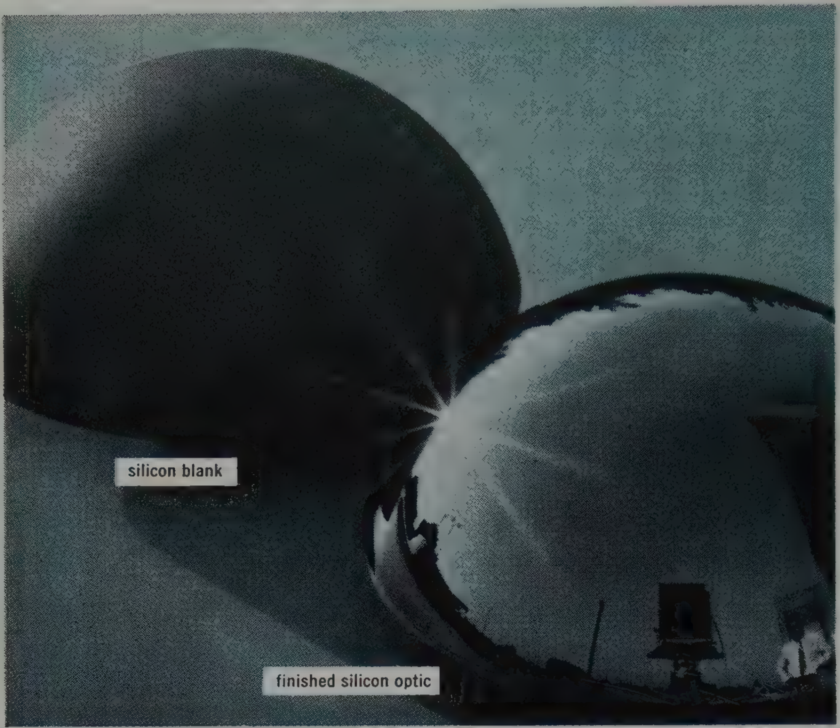
Watchword: Reliability



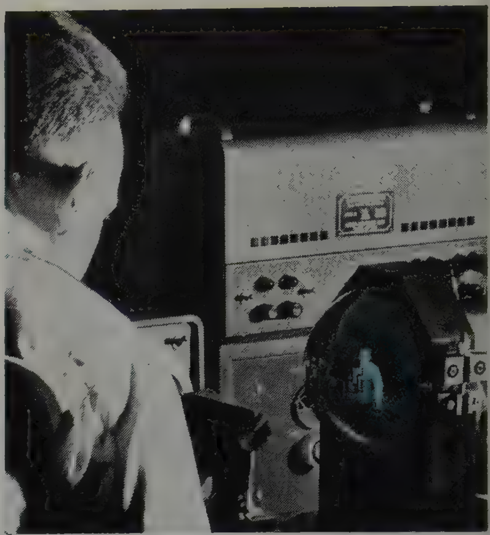


PHOTO COURTESY ACF ELECTRONICS DIVISION ACF INDUSTRIES, INC.

Avion engineer "reflects" on Dow Corning silicon dome during test of infrared transmission characteristics. Avion's capability in infrared technology dates back to early research and development on the famous "Sidewinder" missile. Present interests and projects include airborne detection and tracking devices.

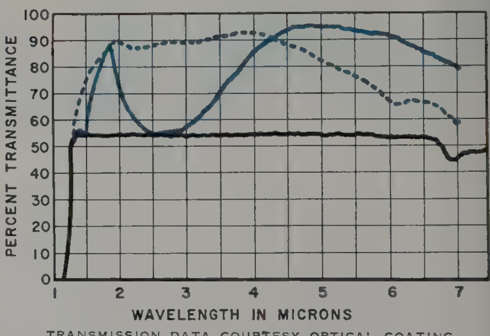
Silicon Optics Enhance Reliability and Versatility of Infrared Detection Systems

As new infrared guidance and surveillance systems take their "passive" positions in our defense, one major design challenge is to guarantee optimum performance of these vital devices. One way is to employ *silicon optics* . . . because, in addition to providing over 95% transmission, they offer a unique *combination of properties* that assure the highest degree of reliability and versatility.

Reliability of product really *begins* with reliability of *sources.* Under Dow Corning's stringent quality control program, each new silicon ingot is meticulously quality-checked for transmission rate . . . and a transmission curve goes right along with every silicon blank delivered.

Today, Dow Corning can make prompt shipment of optical silicon blanks up to 7 inches in diameter . . . in hollow domes, flat plates, prisms and other shapes to meet the most exacting specifications. Keeping pace with the new, fast-moving infrared industry, Dow Corning will apply latest techniques to larger sizes as the needs develop.

Free Brochure Available — plus latest data on optical silicon for infrared detection. Write today . . . your name will be kept on a special mailing list to receive all new bulletins on this subject. Please address your inquiry to Dept. 9504.



TRANSMISSION DATA COURTESY OPTICAL COATING LABORATORY, INC., SANTA ROSA, CALIFORNIA.

The black line indicates the percent of transmittance for silicon is relatively constant from 1.3 to 6.7 microns. Blue lines show how transmission is increased by coating. Single coating provides maximum transmission on a narrow band; several coatings, dotted blue line, give maximum transmission on a broad band.

Properties of Dow Corning Optical Silicon

Specific gravity	2.329 at 25 C
Melting point	1420 C
Hardness	7 Moh
	1150 Knoop
Thermal conductivity	0.39 cal (cm sec. C°)
Thermal expansion	4.15×10^{-6}/C°
Specific heat	0.168 at 25°C
Dielectric constant	13 at 9.37×10^{9} cps
Elastic modulus (Youngs)	19×10^{6} psi
Flexural strength	20,000 psi

NEW *from* Penfield

For Semiconductor and Transistor Manufacture

Pressure Cartridge Deionizer Delivers 18-22 megohm Water at Point of Use

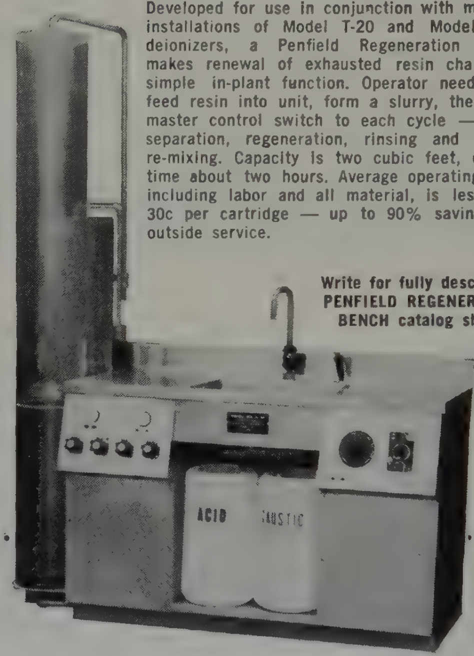
The Penfield PM-8 is a monobed deionizer that "polishes" ultra-high purity make-up and rinse water at point of use. Unique design of top distributor and collector well permits flows up to 50 GPH at less than 4 lb. pressure drop — holds exchange efficiency at 100%. Built entirely of plastic to eliminate metallic contamination. Sump is clear, allowing visual inspection of exchange resins. Cartridge unscrews by hand for easy resin replacement. Unit also can be used as cation exchanger, anion exchanger, water softener, activated carbon filter, oxygen remover or organic scavenger.

Write for fully descriptive PENFIELD PM-8 DEIONIZER catalog sheet.

Resin Separator and Regenerator Saves up to 90% of Costs of Deionized Water

Developed for use in conjunction with multiple installations of Model T-20 and Model PM-8 deionizers, a Penfield Regeneration Bench makes renewal of exhausted resin charges a simple in-plant function. Operator needs only feed resin into unit, form a slurry, then turn master control switch to each cycle — resin separation, regeneration, rinsing and proper re-mixing. Capacity is two cubic feet, cycling time about two hours. Average operating cost, including labor and all material, is less than 30c per cartridge — up to 90% saving over outside service.

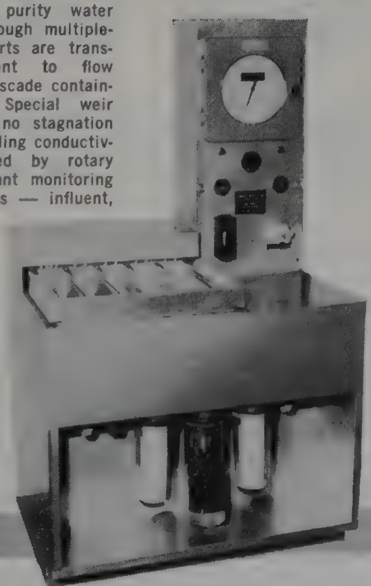
Write for fully descriptive PENFIELD REGENERATION BENCH catalog sheet.

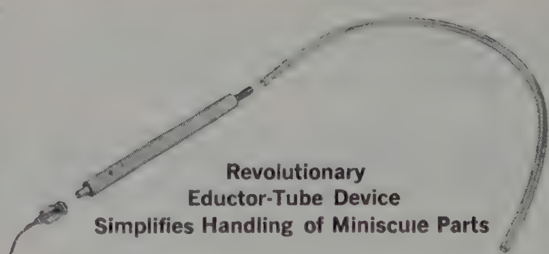


Weir Washer "Polishes" Cascading Water to 18-22 megohms with Instant Monitoring

Integral filters and pressure-type monobed deionizers enable circulation of ultra-high purity water (18-22 megohms) through multiple-partitioned tanks. Parts are transferred counter-current to flow pattern, with each cascade containing purer water. Special weir design insures that no stagnation can occur. Direct-reading conductivity meter, controlled by rotary switch, permits instant monitoring at three check points — influent, deionizer effluent, tank effluent. Novel clip bar makes replacing heating elements simple, obviates need to empty tanks.

Write for fully descriptive PENFIELD WEIR WASHER catalog sheet.





Revolutionary Eductor-Tube Device Simplifies Handling of Miniscule Parts

New Penfield Pickup makes handling of minute particles a simpler, less costly operation. Exclusive design uses air or inert nitrogen forced through a special eductor tube at 1-2 psi. Negative pressure is created at pick-up point (where standard hypodermic needles are attached) sufficient to hold germanium, silicon or other miniscule parts. To release the held particle, operator merely finger-stops an orifice in the pickup, thus creating positive pressure. Use of Penfield Pickups eliminates all foot switches, solenoids and costly vacuum equipment — also does away with troublesome plugging problems.

Write for fully descriptive PENFIELD PICKUP catalog sheet.

Penfield **MANUFACTURING CO., INC.**
19 HIGH SCHOOL AVENUE, MERIDEN, CONN.

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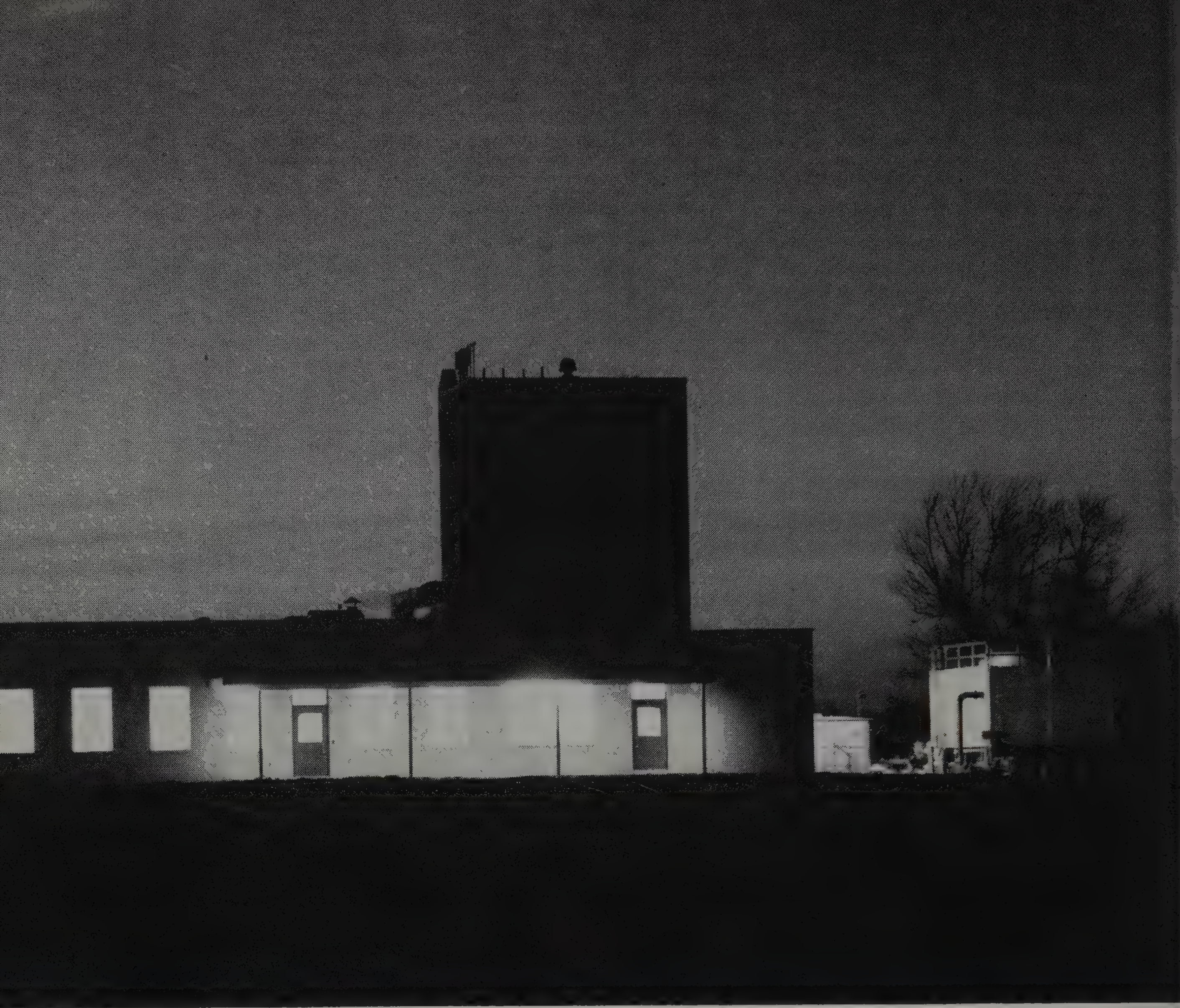

MONSANTO SILICON NOW IN ROUND-THE-CLOCK PRODUCTION FROM THIS NEW PLANT

Now on-stream day and night—Monsanto's new custom-engineered plant near St. Charles, Missouri—turning out semiconductor-grade SILICON.

Check into the form of Monsanto SILICON that best meets your needs:

Float-zone-refined single-crystal SILICON . . . (**a**) *doped* to desired resistivities of either "p" or "n" type and having high lifetimes (**b**) *undoped* high-resistivity (greater than 1,000 ohm cm.) "p" type with lifetime of more than 200 microseconds.

Polycrystalline SILICON . . . (**a**) *rods* designed for float-zone refining and capable of making single-crystal silicon of high-resistivity "p" type, or of being doped to desired levels of "p" or "n" type resistivities (**b**) *billets* with ultra-low base boron content for growing high-quality crystals.

To be certain you keep up to date and have all the information you need about Monsanto's semiconductor-grade SILICON, just write: *Monsanto Chemical Company, Inorganic Chemicals Division, Dept. SI-1A, St. Louis 66, Missouri.*

Monsanto ® SILICON

Circle No. 17 on Reader Service Card

Book

TITLE: Electrical Measurements

AUTHOR: Smith Wiedenbeck

PUBLISHER: McGraw-Hill 1959

Electrical Measurements is a basic manual on the measurement of fundamental electrical quantities. The book can be considered more of a laboratory approach to problems rather than a description of modern techniques.

The first chapter discusses and evaluates errors. Various topics are covered in the analysis, such as precision index, probable error, propagation of errors and weighting of data.

The book continues with chapter two, as a review of elementary electrostatics serving as an introduction to the third chapter entitled: "Ammeter and Voltmeter Methods." Here the basic operation of the ammeter is derived from the electromagnetic field concepts. A description of shunting leads to the voltmeter and methods of resistance measurement. Special problems, such as the measurement of a resistance containing an EMF, are considered as well as the use of the potential divider.

The next chapters describe the various types of instruments in detail. The current galvanometer, ballistic galvanometer, Wheatstone bridge and potentiometer are all very well treated, starting in all cases with material and derivations previously developed for the indicating instruments.

The balance of the book considers *a-c* circuits, the measurement of transient currents, inductance, capacitance and mutual inductance. Chapter XVIII entitled "electronics" concludes the book abruptly since measurement techniques for this field can hardly be described in a mere 36 pages.

Electrical Measurements is a good introductory book on the measurement of basic electrical quantities and appropriate instrumentation. The book is dated somewhat in the complete lack of consideration of certain topics, such as frequency and time, as well as electronic techniques, although an attempt is made in the last chapter to cover the field. The value of the book lies in the thorough and accurate presentation of the material covered which should continue to recommend it as a good basic laboratory measurements manual.

Reviews

TITLE: Basic Electronics

AUTHORS: J. Daly, R. A. Greenfield

PUBLISHER: The Macmillian Company, New York

Basic Electronics is a book written to provide specialists in other scientific fields with a working understanding of the electronic science. This book is one in the series "Physical Processes in the Chemical Industry" and attempts to enlighten the chemical engineer with regard to electronic practice.

The general material is divided into twelve chapters, the first entitled "Direct Current". This title is somewhat of a misnomer since a considerable amount of material is presented that would ordinarily be found under other titles. An example is mutual inductance which is discussed here although chapter II is devoted to magnetism. Self inductance, transient currents and charging circuits are several topics discussed, in addition to appropriate material on insulators and conductors.

A more logical presentation is made in chapter III entitled "Alternating Currents". Vector (phasor) notation is introduced and the definitions of alternating current theory are well presented. Resistance, capacitance and inductance are covered and the resonant circuit is developed. Coupled circuits and transformer action are also discussed.

The next chapters cover a very wide range of topics. The vacuum tube and other thermionic devices such as the cathode-ray tube, the "Dekatron" and the Thyraton are covered in moderate detail. Circuit configurations are discussed in each of the following two chapters which are entitled "Amplifiers" and "Oscillators". A chapter on Semiconductors (chapter X) gives a very brief treatment of the transistor and is only useful to provide a basic understanding of the field.

Basic Electronics is a book that is certainly all the name implies. It is useful for those who want an overall picture of the field and to this end the book satisfies the requirement. Workers in other engineering fields would undoubtedly find the material useful although the electronic technician or engineer might question the organization of material. The actual presentation however is good and an almost total absence of mathematics makes the book highly readable for beginners.

By Stephen E. Lipsky

Now Sylvania grows germanium and silicon doped single crystals for you!

Now device makers can concentrate completely on device making! Sylvania grows germanium and silicon single crystals to your most exacting specifications. You not only get a guaranteed quality material ready to use; you're freed of many manpower, space and time problems. You're freed of the cost and trouble of buying and maintaining special equipment, training manpower, and handling scrap. And you can take full advantage of the engineering excellence of the Sylvania staff!

Germanium single crystals are prepared by either the Czochralski or horizontal techniques. Silicon single crystals are produced by both the float zoning and Czochralski methods.

Single crystal slices of either material are also available.

Resistivity, conductivity type, orientation, lifetime, dislocation density, and size are controlled to meet your requirements.

Sylvania know-how makes these crystals available to you at prices that are predictable and attractive. For details, write to the Chemical & Metallurgical Division, Sylvania Electric Products Inc., Towanda, Pennsylvania.

SYLVANIA

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Personnel Notes

Herbert Fishman has been appointed consulting engineer to the transistor advance and design engineering subsection in General Electric's Semiconductor Products Department, Liverpool, N. Y. Immediately prior to his promotion, Mr. Fishman was a design engineer in the Department's advance process engineering unit. He is a member of Pi Mu Epsilon, mathematics honorary society, the American Physical Society, and a senior member of the IRE.

The directors of Alpha Metals, Inc., Jersey City, have announced the election of Harold A. Cohn as vice president in charge of their Alpha-Loy Division, Chicago. Joining the firm in 1953, Mr. Cohn assisted in setting up the mid-west plant he now heads. He has had wide experience in the field of metals marketing. Fredrick C. Disque, Jr. was named Director of Research. He was formerly Chairman of the Department of Chemistry, Pratt Institute. Before joining Alpha Metals in 1953, he acted as one of their technical consultants, specializing in research and development of solders, fluxes and high-purity metals for the semiconductor industry.

Donald E. Yost has been named works manager for Fairchild Semiconductor Corporation's diode facility in San Rafael, California. In this position he will be responsible for all manufacturing operations there. Mr. Yost was formerly manager of central manufacturing engineering at Lockheed Missile and Space Division, Sunnyvale, Calif. He received his B.S. degree in 1951 from the University of Buffalo, where he became an instructor in electronics.

Appointment of William E. McQueeney as a product specialist in the Field Engineering Dept. of the Sprague Electric Co. has been announced by Carroll G. Killen, manager of the department. Mr. McQueeney's responsibilities will be in the field of electrolytic capacitors, Mr. Killen said. Prior to joining Sprague, Mr. McQueeney was associated with the U. S. Shoe Machinery Co. and, most recently, with the Westinghouse Electric Corp. in Pittsburgh, Pa. He is a graduate of Boston University with a Bachelor of Science degree in physics.

Seymour Weiner has been advanced from Product Planning Manager to Product Engineering Department Head at the Sperry Semiconductor Division, Edmund G. Shower, Division Production Engineering Manager, announced recently. In his new capacity Mr. Weiner will be responsible for engineering all products from the pilot shop phases into production.

A. P. Fontaine, executive vice president of Bendix Aviation Corporation, has announced the appointments of Charles M. Edwards as his assistant and Dr. G. A. Rosselot as assistant general manager and associate director of the Research Laboratories division of the company.

(Continued on page 82)

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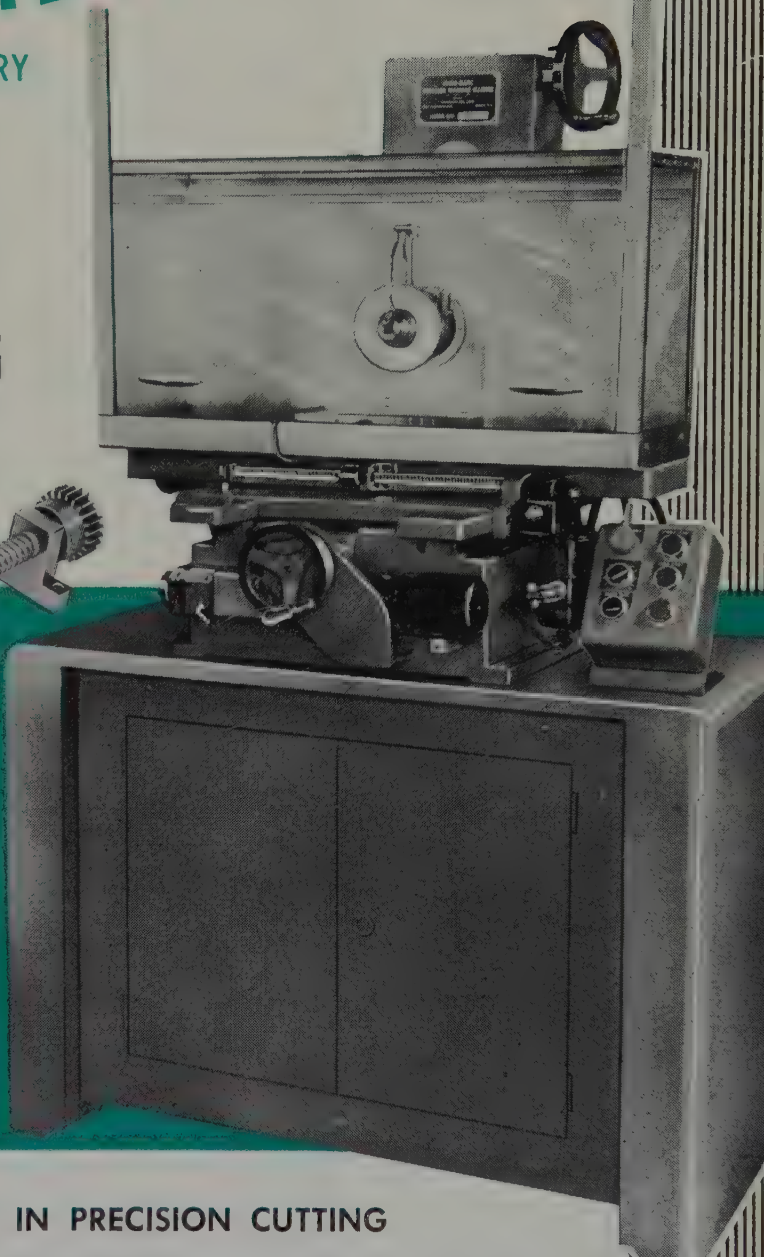

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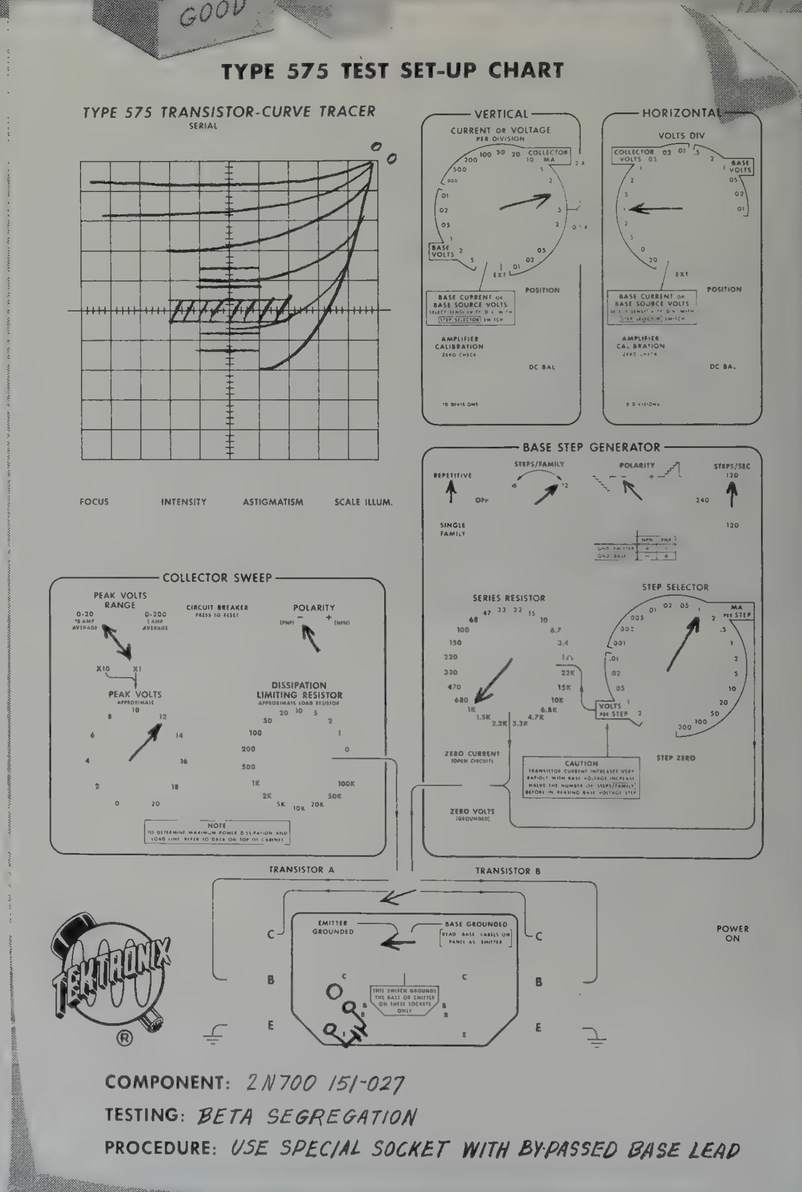

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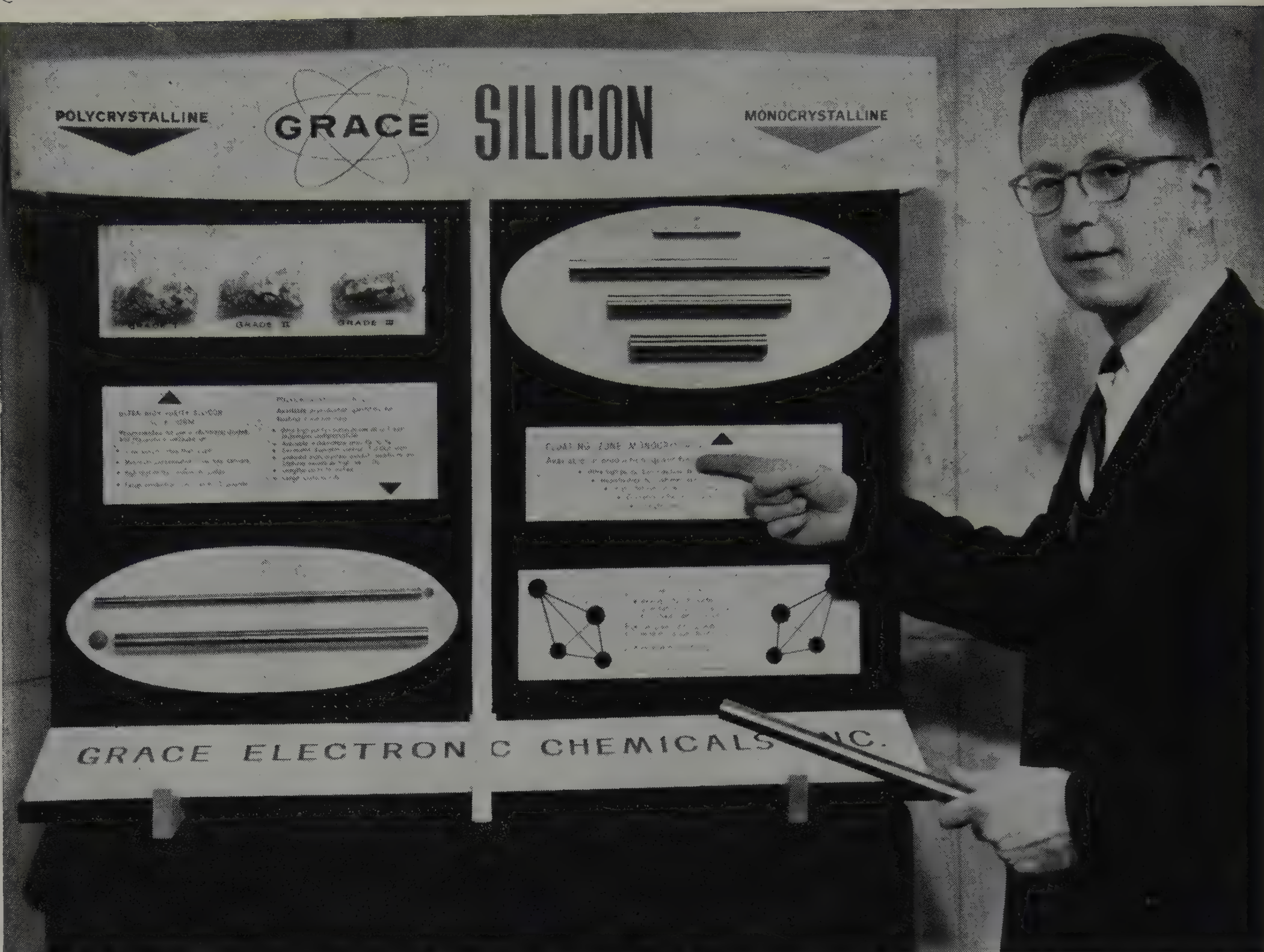

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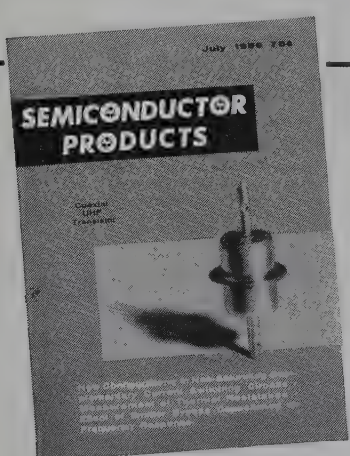

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Market News . . .

Prices

Texas Instruments has announced prices on their five new *p-n-p-n* diffused **silicon** rectifiers.

	1-99	100-999
TI-110	$20.00 ea.	$12.50 ea.
TI-111	24.00 ea.	15.00 ea.
TI-112	36.00 ea.	22.50 ea.
113	55.00 ea.	42.50 ea.
114	65.00 ea.	58.50 ea.

Sylvania Electric Products Inc., Semiconductor Division has placed into production two series of variable capacitance diodes. Each series consists of nine Si mesa diffused junction diodes. Series D4075 to D4075H is priced at $25.00 each to $420.00 each in small quantities. Series D4110 to D4110H is priced from $20.00 each to $280.00 each in small quantities.

Standard Telephones and Cables, Ltd., London, is marketing tunnel diodes in sample quantities up to 50 units per order at $5.60 each.

Industro Transistor Corp., L. I. C., N.Y., has available two diffused Si mesa transistors types 2N696 and 2N697. These are priced at $22.70 each in quantities 1-99 and at $15.15 each in quantities 100-999.

Philco Corp. has reduced prices on its silicon and germanium transistors up to 52%. The largest single reduction was the germanium type 2N502A which dropped from $13.80 to $6.60 in quantities of 1 to 99. The largest number of price drops was in the silicon line, with reductions ranging from 25% for the SADT 2N1267 to 40% for the 2N1199. The 2N1199 is now priced at $15.75 each in lots of 1-99; $11.55 each from 100-999, and $10.50 each from 1000 up.

The Semiconductor Division of Hoffman Electronics Corp. has announced prices on their new silicon solar cells having a conversion rate of 10%. These are selling at $8.25 each in quantities from 100-999. The company also has reduced prices on their 9% conversion silicon cells from $4.90 to $4.65 each in production quantities.

Sylvania Electric Products Inc., has reduced prices on its line of Micro-Min glass-encapsulated microwave diodes from 10 to 30 percent. The IN833 has been reduced from $4 to $3 each on quantities of 100 and over.

Canadian General Electric, Ltd., is offering a 1000 mc tunnel diode at $69 in limited quantities.

Semiconductor Division of Semi-Elements Inc., Saxonburg, Pa., has begun production on five different types of UHF germanium mixer diodes.

Type	Price
DC 7	$1.75
DC 7A	2.50
DC 7B	2.75
DC 7C	2.95
DC 7D	5.95

The Bureau of Mines reports that although production and consumption of high-purity silicon had increased last year over 1958, the demand may drop in the future due to new devices and downgrading of material requirements. Factors affecting this are due to increased activity in: molecular engineering; manufacture of tunnel diodes, and making better use of grades 2 and 3 silicon through improved doping procedures.

Estimated production last year was 80,000 lbs. of the top three grades and 20,000 lbs. of solar-grade type. In 1958 the output was 55,000 lbs. for the three top grades and about 20,000 lbs. for solar-grade.

Consumption of the high-purity silicon was about 70,000 lbs., valued at about $18 million including an estimated $1 million for the solar battery grade. Approximately 6 million transistors and 60 million diodes and rectifiers were manufactured in 1959.

Prices reported were:

Grade	Price Range (per lb.) Granular	Rod
1	$320-330	$330-355
2	220	220-245
3	130	155
Solar	90	-

Fairchild Semiconductor Corp. has made a 25% reduction on its line of single-supplier silicon transistors. Prices on their 2N696 and 2N697 are now $22.70 each in quantities less than 100. Their *p-n-p* general purpose transistor 2N1131 and their low storage *n-p-n* types 2N1252 and 2N1253 are now $28.80 each in small quantity lots. The high voltage *n-p-n* type 2N699 is now also available for $24.95 each.

The General Electric Company has started factory production of germanium tunnel diodes and, as a result, reduced prices on the devices by eighty-three percent. The new prices are $10.00 and $12.50 each, effective immediately. Previously the G. E. tunnel diodes were $60.00 and $75.00 each.

Financial

International Business Machine Corp. has increased their quarterly dividend on common stock to 75¢ from the 60¢ paid previously. This will be paid to stock of record as of February 10.

Sperry Rand Corp., has reported sales of $853,144,550 and a profit of $29,269,110 for the nine month period ending Dec. 31, 1959 as against sales of $697,472,448 and a profit of $18,636,016 for the same period in 1958.

Raytheon Co. has reported earnings for the year ending Dec. 31, 1959 of $13,481,000 on sales of $494,278,000. In 1958 earnings were $9,403,000 on sales of $375,156,000. Earnings per share in 1959 were $3.89 as compared with $3.08 in 1958.

Transistron Electronic Corp. common stock has moved from over-the-counter basis to a listing on the New York Stock Exchange.

Industro Transistor Corp. has reported a profit of $188,131 for the six months period ending Dec. 31, 1959.

Tung-Sol Electric Inc. has announced that the net sales for 1959 was $72.345,248 a gain of 21% over 1958 sales of $59,809,166. Earnings totaled $2,712,552 equal to $2.70 per share as compared with $2,643,842 or $2.67 per share in 1958.

Philco Corporation has reported its 1959 earnings, subject to audit, of $1.67 per share, compared with 61¢ for 1958. Sales increased 13% to $397,849,000 and net earnings after taxes were $7,162,000, compared with $2,874,000 in the recession year of 1958.

General Instrument Corporation recorded net profits of $1,378,233, for the fiscal nine months ending November 30, 1959, which is higher than the entire fiscal year ending last February 28 (when profits totalled $1,317,828). This set an all-time sales record of $41,277,875 for the period; and entered the fourth quarter with a backlog of $33,238,000, highest in the electronics company's 37-year history. Net profits were $1,378,233, up 43 per cent from the 1958 nine-month figure of $960,717. Per share earnings equalled 90 cents on 1,529,473 shares outstanding, compared with 70 cents on the lesser number of 1,373,273 shares in the 1958 nine months. Semi-conductor sales for the nine months were more than double those in the same period last year and semi-conductor backlog, as of November 30, was more than triple the year-earlier figure.

Glass-Tite Industries, Inc. has announced an increase of 190% in earnings during 1959 over 1958 figures. Net sales in 1959 totaled $1,899,445.60 as compared with $667,416.07 in 1958. Earnings after taxes were $139,015, the equivalent of 20 cents per share on the 712,000 shares outstanding. In the 1958 calendar year, net income after taxes was $47,934 or the equivalent of 11 cents a share on 437,500 shares outstanding.

Minnesota Mining & Manufacturing Co. reported today that 1959 consolidated sales were approximately $445,000,000 which represents an increase of about $69,000,000 or 18 per cent, over comparable 1958 consolidated sales of $376,293,016. For the first nine months of 1959, 3M reported consolidated sales of $323,079,201, with earnings of $42,583,641, or $2.50 per share. For the same period of 1958, consolidated sales were $271,366,401, with earnings of $29,568,080, or $1.75 per share.

Sales of the Avnet Electronics Corporation, for the six months ending December 31, 1959 totalled $4,535,000, a 57% increase over sales for the comparable period the previous year, when sales totalled $2,886,000. Net income for the six months ending

(Continued on page 72)

Editorial . . .

Noise Figure of Parametric Amplifiers

Since the introduction of parametric amplifiers, questions have been raised about the actual limit value of noise figure attainable with configurations unilateralized by means of appropriate circulators. Generally these amplifiers are operated on a single-sideband reception mode, i.e. if f_s, f_p and f_{p-s} are respectively the signal, pump and idler frequencies, the signal is introduced and amplified at the frequency f_s only. Since the noise, on the other hand, is originated at the f_s and the f_{p-s} frequencies and is amplified and converted to the f_s band, an inherent limitation results on the maximum permissible value of signal-to-noise ratio. In order to improve the latter a different mode of operation may be devised in which the signal is entered and amplified at both sidebands. This may be done if the input signal is made to have proper symmetry about half the pump frequency and if the circuit impedances are made high at both f_s and f_{p-s} frequencies. Such a suggestion has been advanced recently (M. Uenohara—"Noise Consideration of Variable Capacitance Parametric Amplifier," *Proc. IRE Feb. 1960*) and supported with theoretical and experimental arguments. One example of application of such a mode of operation occurs when the amplifier is used to receive "broadband noise" such as in the case of radio astronomical observations. Improvements by a factor of about two for the resultant signal-to-noise ratio are predicted. Quantitative relations may be obtained using the incremental model of Rowe to express the relations between voltage and current components at f_s and f_{p-s} at the variable capacitance. The latter is assumed to vary sinusoidally with an average "static" value C_o and is assumed to have very small series resistance R_s. It is found that in the proper conditions of operation the variable capacitance diode presents an admittance whose susceptance is cancelled by the susceptance of the signal circuit and whose conductance is negative. The magnitude of the latter conductance depends on the pump power and increases with the value of the quantity $1/\omega_s C_o R_s$, which represents a quality factor for the diode. In fact it is found that no negative conductance may be obtained when the latter factor is less than two. In practice the value of $1/\omega_s C_o R_s$ may be modified somewhat by adjusting the bias, since the static capacitance C_o varies with the latter; however, optimum results are obtained in general with almost zero bias; at the upper limit of the frequency band a slightly negative bias is used.

Comparing operations in the single sideband mode with that in the double-sideband mode it is found that the corresponding noise figures are roughly in the ratio $(1+f_s/f_{p-s}) : 1$; this means that the difference between the figures is less than 3 db if f_s is smaller than f_{p-s} and is more than 3 db in the alternative case. The magnitude of the noise figure becomes minimum at an appropriate value of the pump power, which depends upon the quality factor and decreases as the latter increases.

Samuel L. Marshall

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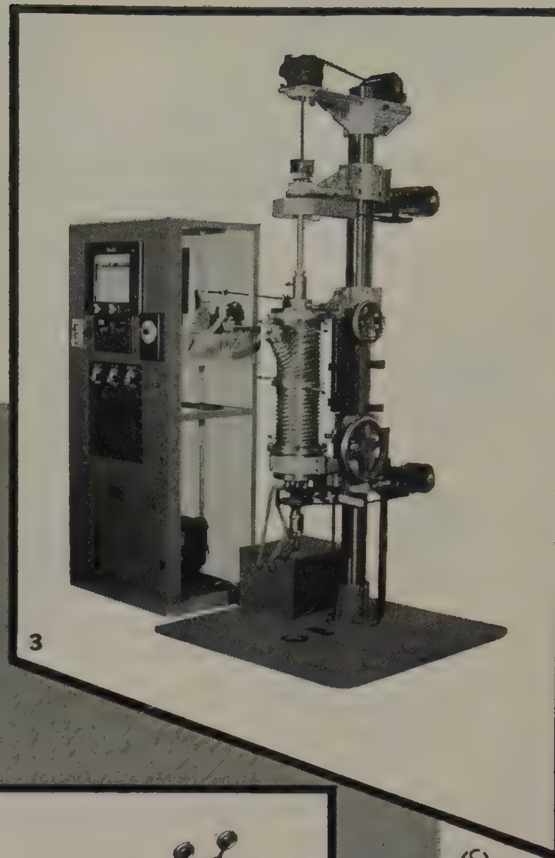

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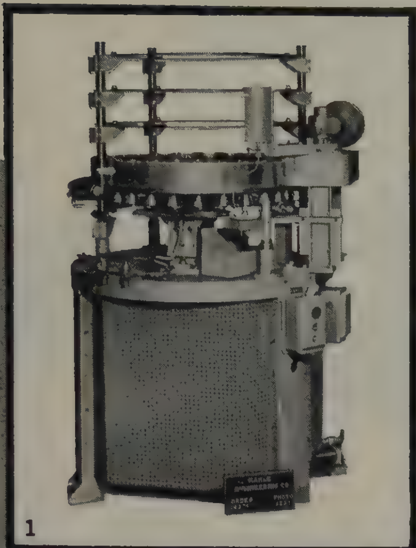

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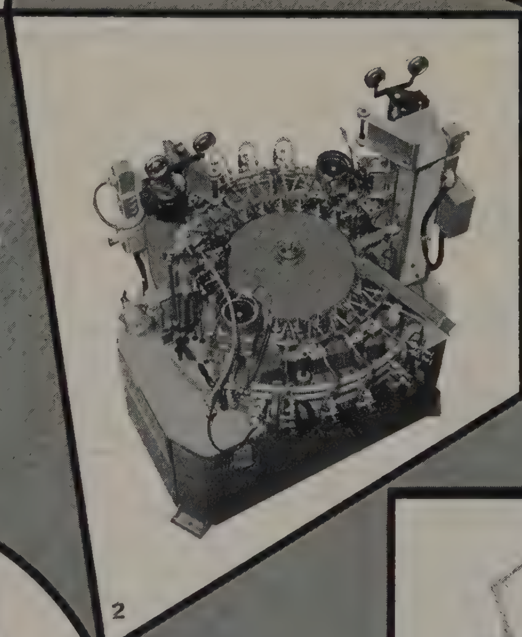

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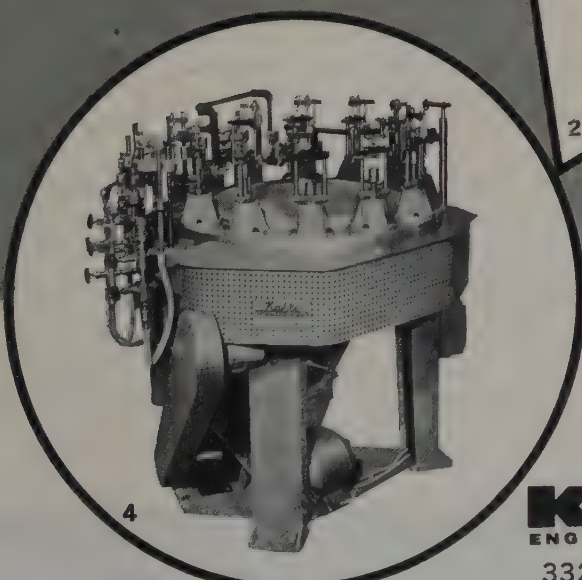

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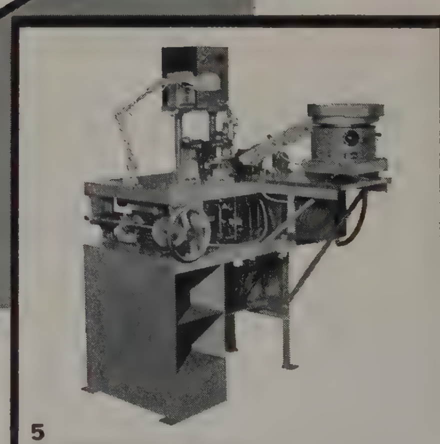

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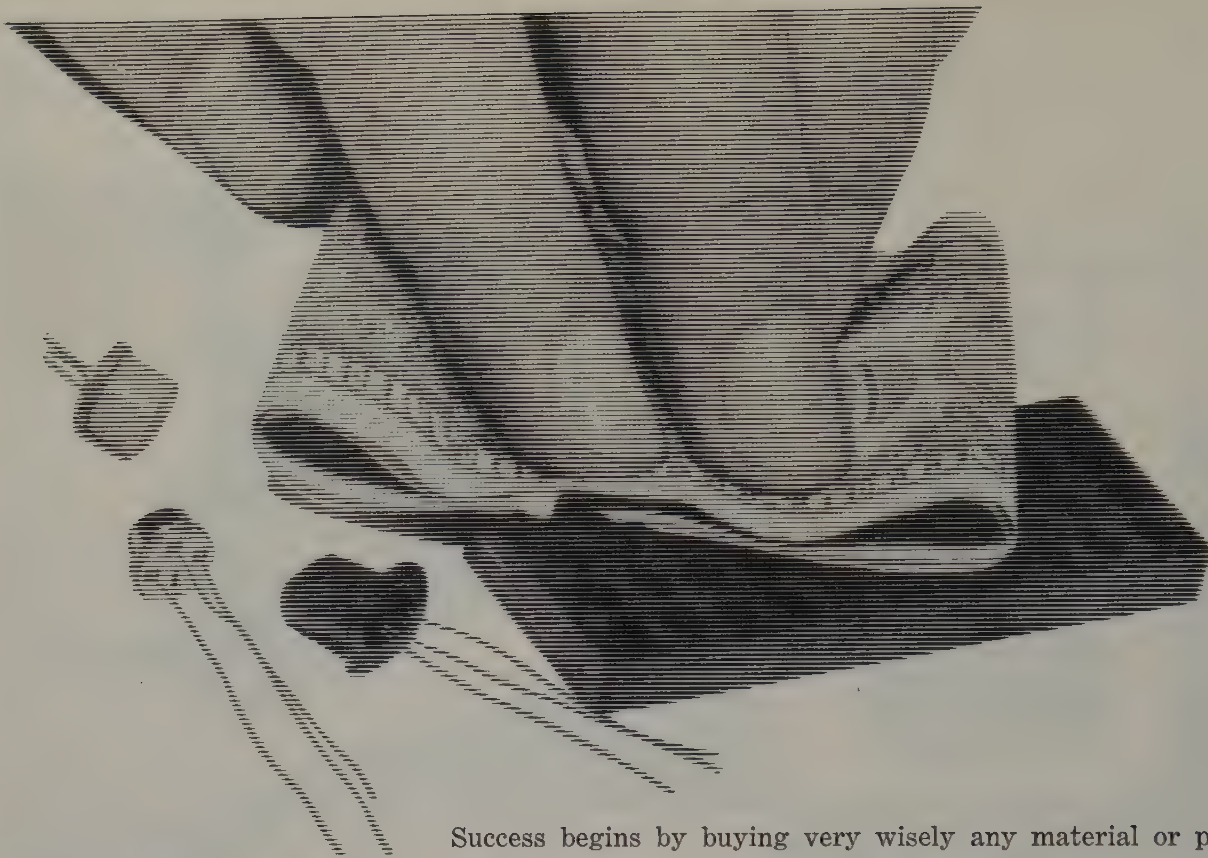

How to "Buy" Success in the Semi-conductor Business

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A Transistor Bidirectional Limiter

HERMANN SCHMID*

The excellent saturation characteristic of junction alloy transistors permits design of precision limiters or switches. A complementary transistor voltage switch can limit an input voltage V_i accurately to 1mV of the limiting potential V_L, in both directions, i.e. to $+V_L$ and to $-V_L$. If the complementary transistor voltage switch is connected to the output of a *d-c* operational amplifier, the limiter circuit will provide extremely high linearity and excellent zero stability. The bidirectional limiter can either accept limiting potentials as far apart as 100V or input frequencies of up to several hundred kilocycles, depending on whether high voltage or high frequency transistors are used.

A BIDIRECTIONAL LIMITER is a device which restricts the excursion of a signal in both the positive and the negative direction to the desired limiting potentials. When the instantaneous voltage of the signal to be limited does not exceed the positive or negative limiting potential, the output of the bidirectional limiter should be equal to the input. The bidirectional limiter can also be considered as a simple function generator useful as an element of a function synthesizer in analog computers.

Performance of Present-Art Bidirectional Limiters

Most conventional bidirectional limiters use vacuum or semiconductor diodes in either the series-diode or shunt-diode circuit.[1, 2, 3] Some use vacuum triodes or pentodes. In all limiters of this type, the accuracy with which the device will limit a signal to a desired potential is always dependent on the performance of the non-linear elements used. When diodes are employed, the accuracy is determined by the forward drop itself or the variation of the forward drop. In vacuum tubes, the accuracy is restricted by the contact potential itself or by the contact potential variations.

A simple bidirectional diode-shunt limiter is shown in *Fig. 1*. When the input signal V_i is smaller than the positive limiting voltage $+V_L$ and larger than the negative limiting voltage $-V_L$, the output voltage V_o it not equal to V_i. Instead, V_o is a function of the resistors R_L and R, and the difference of the reverse currents through diodes D_1 and D_2. When V_i exceeds $+V_L$, it will be seen that V_o is not $+V_L$, but $+V_L$ plus the voltage drop across D_2. Similarly, when V_i is smaller than $-V_L$, V_o is $-V_L$ plus the voltage drop across D_1.

The feedback diode-shunt limiter, illustrated in *Fig. 2*, which may be considered as an operational amplifier in which the circuit of *Fig. 1* is used as feedback

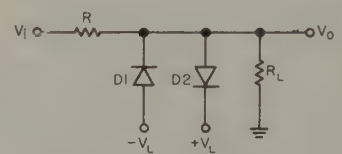


Fig. 1—Simple diode shunt limiter.

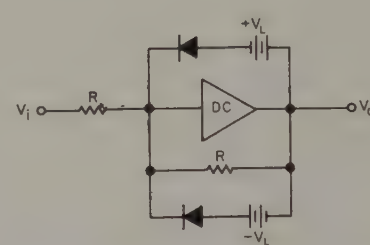


Fig. 2—Feedback diode shunt limiter.

network, has the basic advantages of high input impedance and low output impedance. Further, V_o is exactly equal to V_i, when $+V_L > V_i > -V_L$ and when silicon or vacuum diodes are employed.† However, the circuit has the same shortcomings as the simple diode-shunt limiter when V_i is larger than $+V_L$ or smaller than $-V_L$. Since the voltage drops across the conducting diodes are of the order of 0.1 volt for germanium diodes, or 0.5 volt for silicon diodes, and since the contact potential of vacuum diodes is approximately 1.0 volt, these limiters can perform only to a rather restricted accuracy. This is true, even when the voltage drops across the silicon diode and the contact potential of the vacuum diode are compensated, because the variation of the latter two are

† Germanium diodes have a considerable reverse current, which varies with the reverse voltage applied across the diode. This changes the effective feedback resistance and changes also the gain of the amplifier.

* Link Aviation, Binghamton, New York.

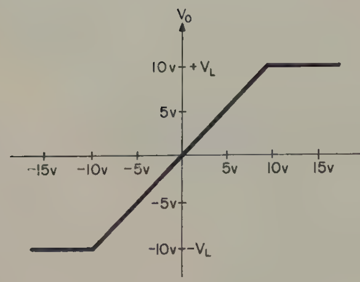


Fig. 3—Input *vs.* output curve of a bidirectional limiter.

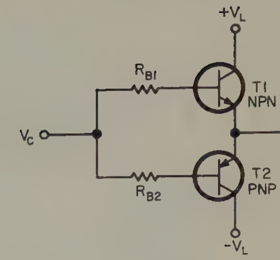


Fig. 4—Simple bidirectional transistor limiter.

still of the order 0.1 volt. The accuracy is especially poor when the signal excursions are small (i.e., smaller than ±10 volts) as is the case with transistor circuitry. The transfer function, i.e. the V_o *vs.* V_i curve of a bidirectional limiter, is given in *Fig. 3*.

The Complementary Transistor Voltage Switch as the Basic Limiter Element

The basic element of the transistor bidirectional limiter is the complementary transistor voltage switch.[4] Since most of the characteristics which make this circuit an almost ideal voltage switch make it also an almost ideal limiter, the operation of the switch is briefly described.

The complementary transistor switch, as illustrated in *Fig. 4*, consists of one *p-n-p* and one *n-p-n* transistor connected at the emitters. In this connection, the two transistors operate almost like an ideal switch. However, the switch is ideal only with respect to its voltage switching capability and not with respect to its current or impedance switching characteristics, thus the name "transistor voltage switch." With this restriction, the operation of the transistor switch can be symbolized by a relay having s.p.d.t. contacts. Like the relay switch, the transistor switch provides a low impedance path between one input, say the collector of *T-1*, and the output, and a high impedance path between the collector of *T-2* and the output, when the control signal, V_c reaches a specified maximum. Similarly, it provides a low impedance path between the collector of *T-2* and the output, and a high impedance path between the collector of *T-1* and the output when V_c reaches a specified minimum. However, unlike the relay switch, the output voltage of the switch will follow the control voltage, V_c, when the switch is in transition (i.e., when $+V_L > V_c > -V_L$). Further, when the polarities of the potentials on the collectors of *T-1* and *T-2* are as shown in *Fig. 4*, the output voltage will be stable or can remain at any value between $+V_L$ and $-V_L$ for any length of time. This is not the case when the polarities of V_L are reversed.

The operation of the complementary transistor voltage switch is described in a concise form in Table 1, where specific values for V_L and V_c are assumed; say $+V_L = +10$ volts, $-V_L = -10$ volts and V_c is varying between +15 volts and −15 volts. In region 1 (15V > V_c > +10V) the emitter-base and collector-base junctions of *T-1* are forward biased and both the collector-base and emitter-base junctions of *T-2* are reverse-biased. This means that *T-1* is conducting (saturated) and *T-2* is cut off; the potential on the collector of *T-1* ($+V_L = +10V$) appears thus at the output. Similarly, in region 2 ($-15V < V_c < -10V$), *T-2* is conducting and *T-1* is cut off; the output voltage, therefore, is $-V_L = -10V$. When V_c is in region 3 ($+10V > V_c > -10V$), one of the transistors operates as emitter follower and the other as load impedance for the first one. When V_c is positive with respect to ground, *T-1* operates as emitter follower and *T-2* as load; when V_c is negative the functions of *T-1* and *T-2* are reversed. In both cases the output follows V_c closely (within $0.1V$).

A transistor is said to be conducting (saturated) when both its base-emitter and base-collector junctions are forward biased. The voltage between the collector and the emitter of the conducting transistor, V_{CE}, is a measure of the switching quality; for most germanium alloy transistors, V_{CE} is of the order of $1mv$,[5] when the load is larger than 100K ohms.

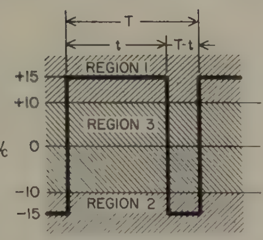
A transistor is said to be cut off when both its base-emitter and base-collector junctions are reverse biased. The current flowing through the cut-off transistor is also a measure of the quality of the switch. However, when the circuit is used as a voltage switch and the current through the load resistance is considerably higher than I_{co} of the cut-off transistor, this is of no great significance.

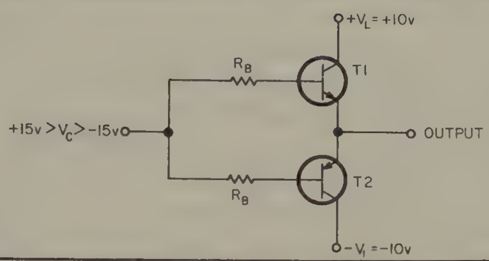
From the above mentioned, it follows that the complementary transistor voltage switch can limit a signal which is connected to the bases of *T-1* and *T-2* very accurately to the potentials on the collectors of *T-1* and *T-2*. The output of the switch follows the input at all times when $+V_L > V_C > -V_L$, but only to approximately $\pm 100mv$. Besides, the *d-c* output potential is subject to temperature variations. In cases where the *d-c* potential of the output is of no significance, as is the case for rapidly varying waveforms such as square waves, the complementary transistor voltage switch, as a single device, will function as a very accurate bidirectional limiter.

The Operation of the Transistor Bidirectional Limiter

Since, in most applications, the *d-c* level of the out-

Table 1. Conditions in the complementary transistor voltage switch during the various phases of operation.





Region 1: $+15v > V_C > +10v$	**Emitter and collector of T_1 are forward biased and thus T_1 conducts. Emitter and collector of T_2 are reverse biased and thus T_2 is cut off. Output stays at $+10v$.**
Region 2: $-15v < V_C < -10v$	**Emitter and collector of T_2 are forward biased and thus T_2 conducts. Emitter and collector of T_1 are reverse biased and thus T_1 is cut off. Output stays at $-10v$.**
Region 3: $+10v > V_C > -10v$	**T_1 functions as emitter follower when $V_C = +$ T_2 functions as emitter follower when $V_C = -$ T_1 functions as load impedance when $V_C = -$ T_2 functions as load impedance when $V_C = +$ Output follows V_C**

put voltage from the bidirectional limiter is of great importance, the complementary transistor voltage switch has to be connected into the forward path of a low drift, high gain, *d-c* amplifier, as illustrated in *Fig. 5*. In this connection, the output of the transistor switch follows faithfully, but with reversed sign, the input voltage V_i, when $+V_L > V_i > -V_L$. This is obvious since in any feedback loop in which the gain is high, the relation between input and output is always linear when the element in the feedback path (resistor) is linear. It has been pointed out before that the transistor switch operates as an emitter follower when V_i is between $+V_L$ and $-V_L$. The difference between the output voltage of the *d-c* amplifier V_B and the output voltage of the transistor switch V_o is the voltage drop across the transistor switch. When $+V_L > V_i > -V_L$, where one of the switching transistors is working as emitter follower, this voltage drop is less than 100*mv*; but when V_i is more positive than $+V_L$ or more negative than $-V_L$, the voltage drop may be several volts.

When the input voltage V_i decreases, and becomes negative and V_B becomes more positive than the positive limiting potential $+V_L$, transistor *T-1* begins to conduct, i.e., the current from the *d-c* amplifier is flowing into the collector of *T-1*. This has the same effect as when the feedback resistance of the *d-c* amplifier is increased, which in turn raises the output voltage of the amplifier.

A more positive output voltage, however, increases the current flowing into the collector of *T-1*, which will further increase the effective feedback resistance, and so forth, until the output voltage reaches saturation. Since the emitter-base junction of *T-1* is already forward biased, when V_B is positive, *T-1* conducts (saturated) as soon as the collector-base function becomes forward biased. At the same time, the base-emitter junction of *T-2* becomes reverse-biased and since the collector-base junction was already reverse biased, *T-2* is cut-off. With *T-1* conducting and *T-2* cut-off, the two transistors operate like a switch and the potential on the collector of *T-1*, $+V_L$, is connected to the output and remains there until V_B ($\approx -V_i$) becomes negative with respect to $+V_L$.

In a similar fashion, *T-2* conducts and *T-1* is cut off when $-V_B$ ($\approx +V_i$) is negative with respect to $-V_L$. In this case, $-V_L$ is connected to the output.

In both cases when V_i is more positive than $+V_L$ and more negative than $-V_L$, the *d-c* amplifier is driven into saturation. This is not desirable because it will take some time, especially in chopper-stabilized *d-c* amplifiers, to bring the amplifier back into the linear region. This would seriously reduce the maximum frequency of V_i. Another drawback is the fact that the saturation voltage of the amplifier might be high and thus produce large reverse voltages across the switching transistor, which in turn might damage the latter. It is thus desirable to limit the voltage excursion of the maximum limiting potentials. This can easily be achieved with conventional zener diodes, as shown in *Fig. 5*. The slope of the input-output ($V_i - V_o$) curve, as given in *Fig. 3*, can easily be changed by varying the ratio between the input resistor R_1 and the feedback resistor R_f. If R_f is infinite, the slope of that curve is infinite also and the circuit is referred to as a "Bang-Bang" circuit.

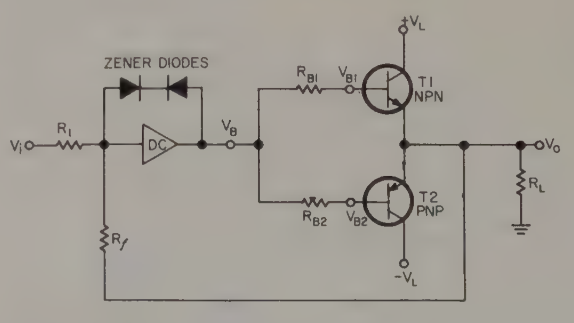


Fig. 5—Schematic of the high accuracy bidirectional limiter.

Performance of the Transistor Bidirectional Limiter

The transistor bidirectional limiter performs just as accurately as the *d-c* amplifier alone, when the input voltage is exceeding neither the positive nor the negative limiting voltage. When the input voltage V_i exceeds $+V_L$ or $-V_L$, the output voltage is almost exactly the limiting potential. The amount by which it differs from V_L is the voltage drop across the conducting transistor V_{CE}. V_{CE} is, for most germanium alloy junction transistors, of the order of $1mv$. With the transistor switch connected into the feedback loop of a *d-c* amplifier V_{CE} is largely independent of the variations of R_L, R_B, R_f and V_L.

The question remains, what happens when the magnitude of V_i equals the magnitude of V_L, or is very close to it? It has been mentioned before that the circuit becomes regenerative when $|V_i|$ is equal or slightly larger than $|V_L|$. This means that the amplifier output voltage V_B is not stable when it reaches V_L. In fact, it goes very rapidly from the linear region into saturation, and this happens when $|V_i|$ is exactly $|V_L|$. In other words, the corners of the input-ouput curve in *Fig. 3* are very precisely defined.

The maximum frequency with which the input signal V_i can vary is in most cases limited by the frequency response or the bandwidth of the *d-c* amplifier. The frequency response of the transistor switch alone must be discussed for the case where the amplitude of the input signal is (1), smaller than, and (2), larger than, the amplitude of the limiting potential. While in the first case the transistor switch is operating as an emitter follower and the frequency response of it is determined mainly by f_{ac}, in the second case the transistor switch saturates and thus the frequency response is a function of how much the switch is saturated and on how fast this charge cn be removed again. This in turn depends on the base input circuit and f_{ac}.

The maximum voltage difference between the limiting potentials $+V_L$ and $-V_L$, with present-art transistors, can be as large as 100 volts ($\pm 50V$). This is dependent only on the maximum collector-to-base, collector-to-emitter and emitter-to-base breakdown voltages[6] of the switching transistors. It is, however, required that the potential on the collector of *T-1* be positive with respect to the potential on the collector of *T-2*, irrespective of ground.

It is further necessary that the limiting potentials come from a low source impedance, preferably from a source of less than 50 ohms.

The dynamic range of the transistor bidirectional limiter, with $50v$ maximum output and $1mv$ minimum output, is of the order of 50,000.

While dynamic range is mainly a function of the breakdown voltages between the electrodes of the switching transistors, the frequency response of the switch is a function of f_{ac} and the base input circuit. Since, however, transistors with high breakdown voltages between the electrodes necessarily have a low f_{oc} only a compromise between maximum dynamic range and maximum frequency response can be obtained. With general purpose, germanium alloy junction transistors such as the 2N43 as the *p-n-p* and the 2N94A as the *n-p-n* unit, a dynamic range of 20,000 and a frequency response (amplitude 3 *db* down) of $200kc$ had been measured when the input signal exceeded the limiting potential. These figures do not indicate the maximum performance of the device but rather the performance with general purpose transistors.

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The Magnetic Reset Control of Silicon Control Rectifiers

BARUCH BERMAN*

The reset scheme of control of self-saturating magnetic amplifiers offers advantages such as fast response and versatility of control signals. Either a-c or d-c may be used to control the reactor. When a reset controlled saturable reactor is adapted to control the firing of a rectifier such as G.E. Type C35B or others of the same physical and electronic characteristic, a high power, high gain, fast response compact package is obtained, which has input-output characteristics largely independent of input line and frequency variations. The reactor output presents a steep wave front to the gate circuit of the controlled rectifier allowing precise determination of the firing angle. Wide range of control and high power amplification is an inherent feature of the package. Complete isolation is established between signal and power circuits.

The Firing Reactor

The basic circuitry of the firing reactor is shown in *Fig. 1* for half wave operation.

The circuit consists of a small isolation step-down transformer, supplying both the control reset winding "A" and the gate supply winding "B" of the reactor *L1,* two small silicon rectifiers, and resistors R_m and R_o. R_m forms a path for the magnetizing current and insures against undesirable firing of the controlled rectifier, which forms the external load R_G. R_o limits the gate current and shapes the load line for correct operation under extreme conditions. An important feature of this reset circuit is that no change of magnetization occurs during conduction of the output winding. A drawback of *mmf* controlled magnetic amplifiers is their slow response to control signals. The inductance of the control winding causes a delay of the control *mmf* build up. The reset amplifier is controlled by the signal voltage. The control source is not actually engaged in the magnetization of the transformer core. Operating power is derived from the supply transformer *(T1)* while the signal voltage acts as a reference standard. The control current of winding "A" is dependent solely on the properties of the magnetic core and rectifier leakage. If very narrow loop magnetic cores are used tremendous power gains are possible with no sacrifice of response.

In the circuit shown in *Fig. 1,* during the first half cycle terminal #3 of *T1* is positive and winding "B" is biased for conduction. Terminal #5 on *T1* is also positive, but the rectifier associated with winding "A" is reverse biased, and no current can flow in winding "A" due to transformer *T1* voltage. During the second, or negative half cycle, terminal #4 of *T1* becomes positive and no load current can flow. Terminal #6 of *T1* becomes positive and control current will flow in an amount dependent on the control impedance or voltage.

An important relation is

$$\frac{e_2}{e_1} = \frac{n_A}{n_B} = R$$

where n_A = control turns

n_B = gate turns

Consideration of minimum control resistance may require that e_2 be higher than Re_1. This will increase the back bias on the control circuit rectifier.

The output current of the circuit shown in *Fig. 1* is a controlled half wave rectified sine. *Fig. 2* is an oscillogram of this current flowing through the controlled rectifier gate. No current flows during the negative half cycle in either direction. This feature is important when operating with controlled rectifiers. Positive voltage on the gate circuit of the controlled rectifiers during the negative half cycle of rectifier supply causes increased and unnecessary losses which may eventually lead to the controlled rectifier running away. Inverse voltage on the gate circuit may damage the gate circuit.

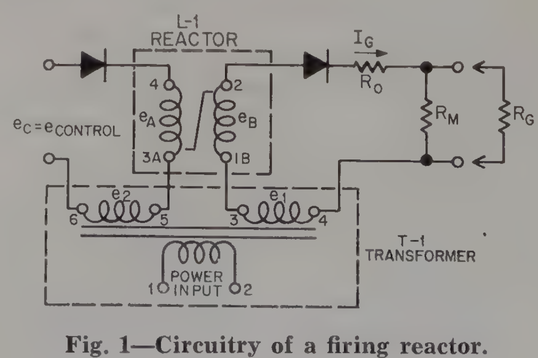

Fig. 1—Circuitry of a firing reactor.

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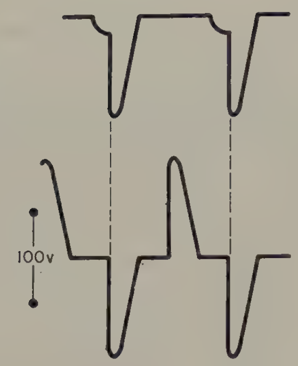

Fig. 2 (Top)—Current through controlled rectifier gate.

Fig. 3 (Bottom)—Full wave *a-c* load current.

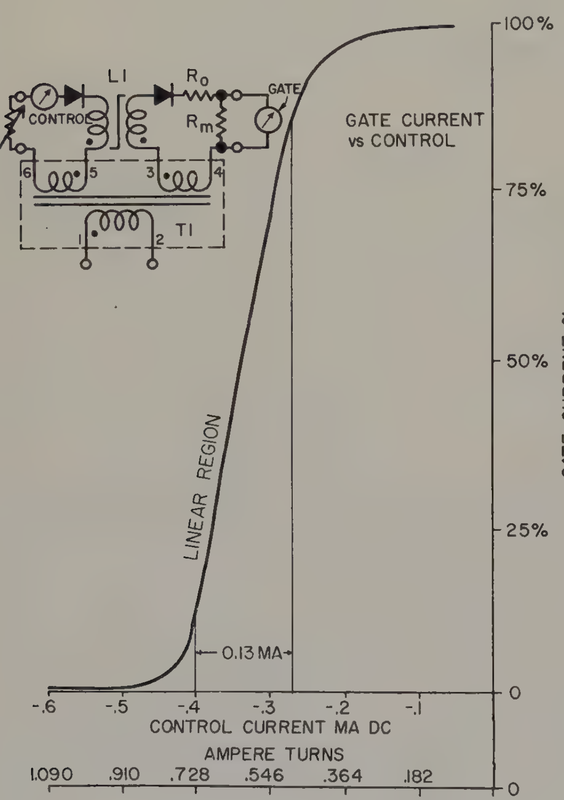

Fig. 4—Firing reactor characteristic.

Fig. 3 shows the oscillogram of the resultant full wave *a-c* load current controlled by the signals supplied by two (2) units each having the output as shown in *Fig. 2*.

During non-conduction (before saturation):

Positive half cycle $e_1 = e_B$

Negative half cycle $e_2 = Re_1$

$$Re_1 - e_c = e_A = Re_B$$

During conduction (after saturation):

Positive half cycle $e_1 = I_G R_G$

Thus, before saturation $|e_1| = |e_B|$ in magnitudes and during the negative half cycle $|e_1| - \frac{|e_c|}{R} = |e_B|$. During saturation the reactor voltage $e_B = 0$.

Fig. 2 (top) is an oscillogram of output of the magnetic reset circuit as it appears across the gate circuit of the controlled rectifier. Firing angle shown is 110°. Peak signal voltage is 10*v*, which is in series with the load line shaping resistor R_0 (see *Fig. 1*).

Fig. 3 (bottom) is an oscillogram of the controlled rectifier output into a resistance load. The response is instantaneous. Full wave *a-c* output is shown. Scale: 1″ = 100V.

The firing angle Θ_n, is given by:

$$\text{Cos } \Theta_n = \frac{2\,|e_c|}{|Re_1|} - 1 \qquad n \text{ — subscript for half cycles}$$

The firing angle is dependent on the control voltage of the preceding half cycle. Thus, the time for full response is one cycle in a half wave circuit or a half cycle in a full wave circuit. The output magnitude will be independent of supply voltage.

The control signal is integrated during the non-firing half cycle. A duration of one half cycle is long enough to allow the core to distinguish between command and noise, making the signal to noise ratio very high. This feature simplifies the work of the design engineer in that each job does not become a project which has to be shielded from noise interference in a particular and unique way. Line transients, created by prime mover-generator imperfections or by other switching loads, commutator noise, and capacitance to ground that usually interfere with reliable unit operation are reduced to an insignificant value.

The circuit shown in *Fig. 1*, may be engineered into a variety of control circuits designed to cover a multitude of functions, such as position controllers and indicators, speed control of *a-c* and *d-c* motors, voltage control of line and voltage control of generators, whether *a-c* or *d-c*, lighting and illumination control, power supplies, half wave and full wave switches for *a-c* and *d-c*, current regulators and various servo applications.

Fig. 4, shows a normalized transfer curve of the half wave reset reactor package. The curve shows average output current *vs* average control circuit current and control circuit ampere turns. The output current is the gate current of the controlled rectifier. The control current, in milliamps *d-c*, is the current required to reset the reactor for different values of output. The maximum current may be computed as follows:

$$H_c = \frac{1.2\, I_c N_A}{l}$$

$$I_c = \frac{H_c l\, 0.8}{N_A}$$

Where:

H_c = Coercive force of the material, in oersteds
l = Mean core length (magnetic) in centimeters
N_A = Number of turns of the control winding
I_c = Control current-amperes.

Allowance is made for deviation of the material from the "square loop," and for the widening of the hysteresis loop due to the cyclic variation of the voltage and control.

The control characteristic shown in *Fig. 4*, is shifted negatively on the control current axis by approximately .45 ampere turns. This is due to the fact that there is some finite control current flowing during the saturation interval of the core. The shift is affected also by the rectifier inverse leakage. In the circuit under discussion the rectifiers in the gate circuit are subjected to very low inverse voltages as compared with their rated peak inverse voltage, and can be assumed to have zero reserve currents. Therefore, their contribution to shift is nil. However, a shift caused by these rectifier leakages, when present, is in the positive direction and thus has the nature of negative feedback.

On the other hand it should be noted that, when the core saturates early in the cycle, full inverse voltage is impressed on the rectifier incorporated in the control circuit. Thus, some finite control current will flow, through the negatively biased rectifier. The polarity sense of the control winding is such that this current will cause an aiding *mmf* to be impressed on the core causing the negative shift of the transfer curve. A core feedback factor has to be known before the absolute value of control current, with no bias applied or contemplated, can be computed.

For the single core half wave assembly shown previously:

$$I_c = \frac{H_c l \; 0.8}{N_A}$$

$$I_c = \frac{0.3 \times 9.47 \times 0.8}{1820} = .125 \; ma$$

$$I_c N_A \cong .23 \text{ ampere turns.}$$

The negative *mmf* equal to the shift may be formalized as positive bias. A fixed resistor R_c is inserted to effect a negative bias. This resistor may be also used for accepting a control voltage if desired. The amount of negative bias can be so set as to allow an input of changing polarity to cause an output duplicating it; i.e. a positive signal, or a signal of identical polarity and phase as e_2 will cause the output to be low. At no signal the output will be half of maximum and with a signal opposing e_2 the ouput will be full.

R_c may be computed as follows:

$$R_c = \frac{(e_2 - e_R) \times 0.45}{I_c}$$

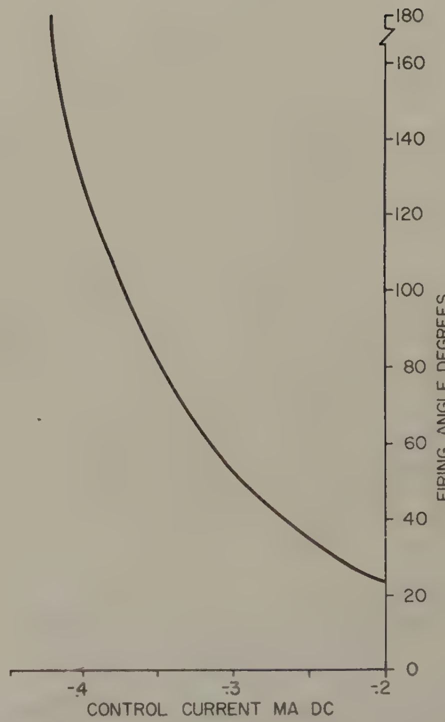

Fig. 5—Firing angle *vs.* single reactor control current.

where:

0.45 = half wave Form Factor
e_R = rectifier drop ($\approx$ 0.7v. for silicon)
e_2 = 18*v. rms* nominal (transformer terminals 5-6), and I_c set for just compensating the positive inherent bias, i.e., 0.45 ampere turns

$$I_c = \frac{0.45}{1820} = 0.25 \; ma \text{ (single reactor)}$$

$$R_c = \frac{17.3 \times 10^3}{0.25} \times 0.45 = 31{,}100 \text{ ohms} \approx 31\text{K}$$

Of more interest, when the unit is used to fire control rectifiers, is the relation between the *firing angle* and the control quantity.

Fig. 5, shows the relation between the control current and the firing angle.

The firing angle of the reactor, and therefore, of the controlled rectifier also, is independent of the gate circuit impedance. If desired, the dissipation in the gate circuit can be further trimmed with resistor R_c to suit desired conditions dependent on applicable specifications. However this will seldom be necessary.

Additional control or bias windings may be added to allow for programming, compensation or performing a variety of functions, all within the space factor limitations.

Figs. 6 and *7* indicate typical operation of a complete package or circuitry incorporating the magnetic reset unit as well as the controlled rectifier.

The output as shown on *Figs. 6* and *7* is full wave *d-c*, unfiltered. The control of the reset circuit is set with a resistor. A transistor control will bring about the same results as obtained with a resistor due to

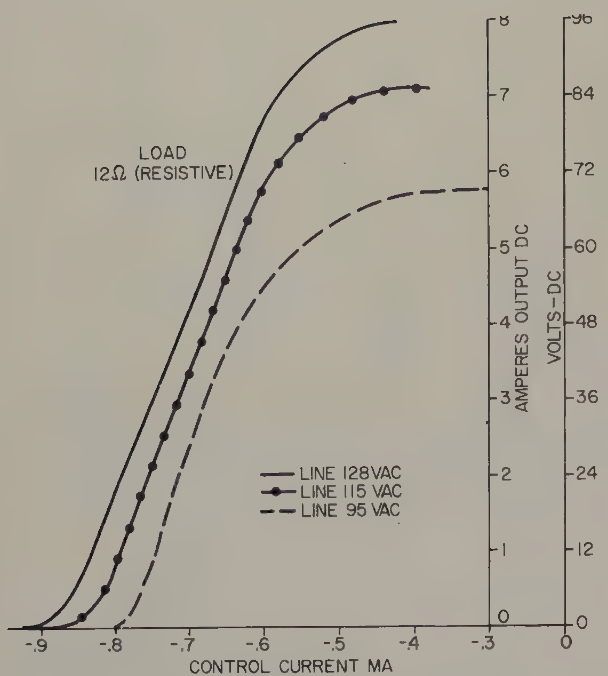

Fig. 6—Average characteristic of controlled rectifiers with magnetic reset; 60 cycle operation.

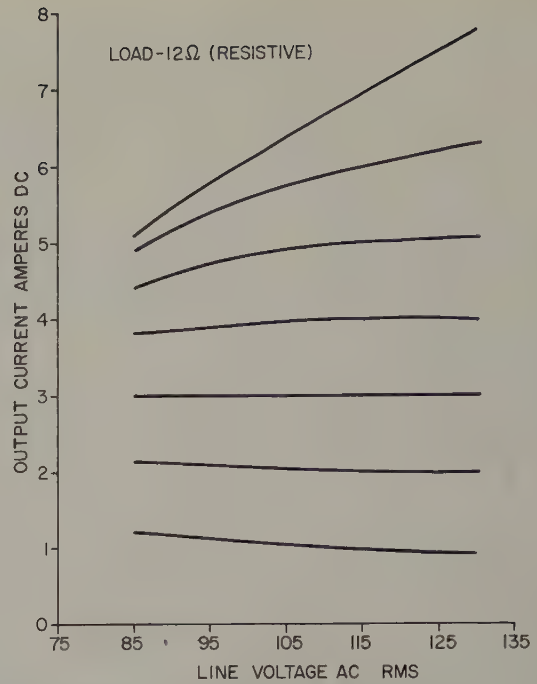

Fig. 7—Variation of average output current and voltage with varying line; 60 cycle.

the fact that both control the reset in the same mode.

The curves of *Fig. 6* were taken with resistive load. The striking similarity of the curves to the typical output of a magnetic amplifier is noted. Of interest here are the obvious superior characteristics of the package as compared with magnetic amplifier output curves.

The quiescent minimum current is zero. This is due to the fact that no exciting current is needed to induce a counter *emf* which will support the voltage across the rectifier, whereas a magnetic amplifier draws a certain amount of exciting current (except in specially arranged circuits). The voltage drop is very low and, therefore, the saturation voltage available for maximum load is higher than with most magnetic amplifiers utilizing the better oriented steel alloys.

The gain is high, and the time constant is short, i.e. the figure of merit "*M*" is very high.

$$M = \frac{K}{T}$$

where K = gain

T = time constant.

Higher gains are easily achieved by reducing the load impedance, while providing for larger cooling fins, forced air draft or by using rectifiers of higher voltage rating. These rectifiers do not increase the gate circuit loading, thus allowing an increase in power available from the same package with no increase in signal power.

It is shown on the linear region of the nominal voltage curve (115*v*) (*Fig. 6*) that the power available is 430 watts, *d-c*. This power is obtained by swinging the total control signal over a range of not more than 0.25 *ma d-c*. The voltage on each control winding is approximately 11 *v. rms*. Thus the signal absorbed by the control winding is

$$11 \times 0.25 \times 10^{-3} \times 0.85 = 4.7 \text{ milliwatt}$$

The response is one half cycle

$$K = \frac{430 \times 10^3}{4.7} = 91.5 \times 10^3$$

$$M = \frac{91.5 \times 10^3}{0.5} = 183 \times 10^3 \text{ per cycle}$$

M was obtained by relating control circuit power to the output of one and the same nominal source supplying both. The control signal power was not drawn from the signal source, but from the supply transformer. If considered with respect to the signal source, the gain can be made theoretically infinite.

Fig. 7, relating average output current with respect to *a-c* supply voltage shows a relatively constant output with varying line input. At approximately 50% of maximum output the regulation is flat. Below that the output curves have a negative slope while above the 50% level the slope becomes positive and finally at saturation, the load current follows the line voltage, as would be expected.

Fig. 7 points to the self-compensating properties of the power pack. The input line is allowed to vary from 85*V* to 130*V a-c, rms,* a range covering more than the variation expected on the softest line. These characteristics of constant average output, with varying input may be exploited very advantageously for uses such as non-regulated power supplies, rotating

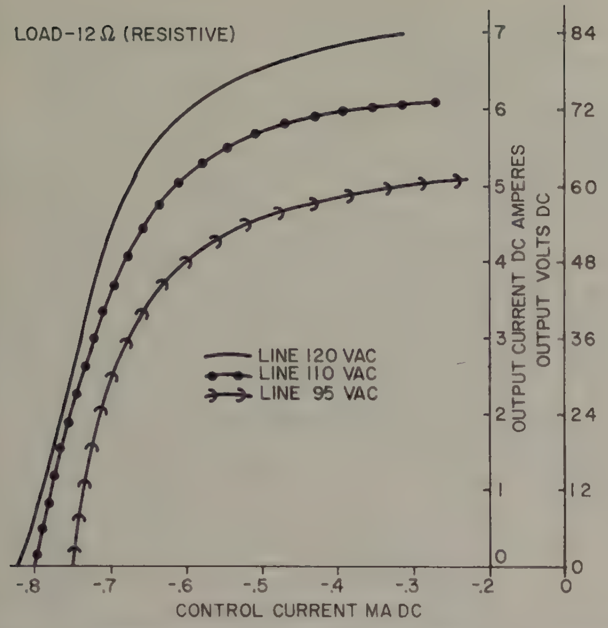

Fig. 8—Average output current and voltage *vs.* control current, 400 cycle operation.

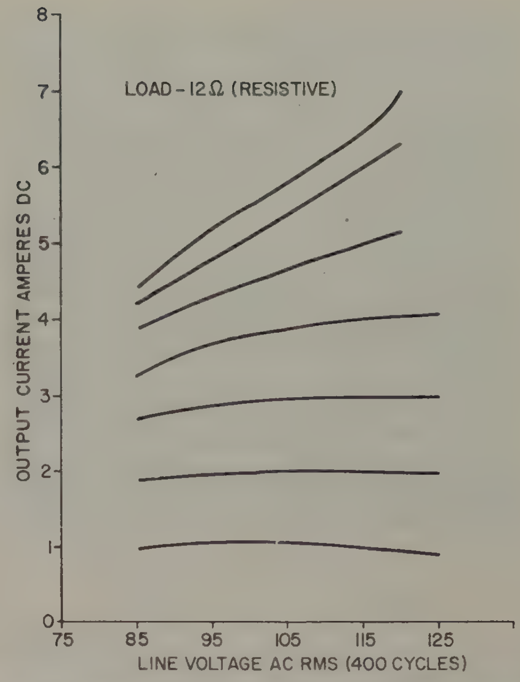

Fig. 9—Average output current *vs.* line voltage. (400 cycle)

equipment field and armature supplies, magnet and clutch coils, cathodic protection loops, and many more. All of the preceding are accomplished without the complexity of closed loops.

Many lab supplies, shipboard supplies and especially airborne supplies are 400 cycle. The power pack will operate, without any modification, at 400 cycles and at any frequency between 40 cycles and 500 cycles. Curves in *Figs. 8* and *9* and *10* show the characteristics obtained at 400 cycles.

Another interesting application is described below where silicon controlled rectifiers are used in *a-c* servo motor drives. *A-C* servo motors are generally designed with high rotor resistance. The rotor resistance shapes the torque-speed curves in such a way as to make the motor suitable for control applications.

A high rotor resistance reduces the possibility of single phasing with no control voltage applied to the control phase of the motor and provides increased internal motor damping, thus reducing stability problems.

Fig. 11 shows a characteristic curve of a Diehl servo motor. The motor is rated 16 watts output and has a synchronous speed of 1800 *rpm*. The input watts are divided between the control phase and reference phase. The reference phase is kept constant, though shifted with a capacitor, to obtain the two phases required for motor control. The maximum output watts are delivered between 1300 and 900 *rpm*.

The torque developed by the servo motor is proportioned to the voltage applied to the control phase and to the speed. The stall torque is directly proportional to the control phase voltage. Thus an amplifier having variable output voltage and low output impedance is a suitable implement for the servo motor control. In practice, servo motors are not ideally linear. Torque varies with temperature, internal damping varies with speed and voltage, input impedance varies with speed and voltage and the torque sensitivity varies with voltage.

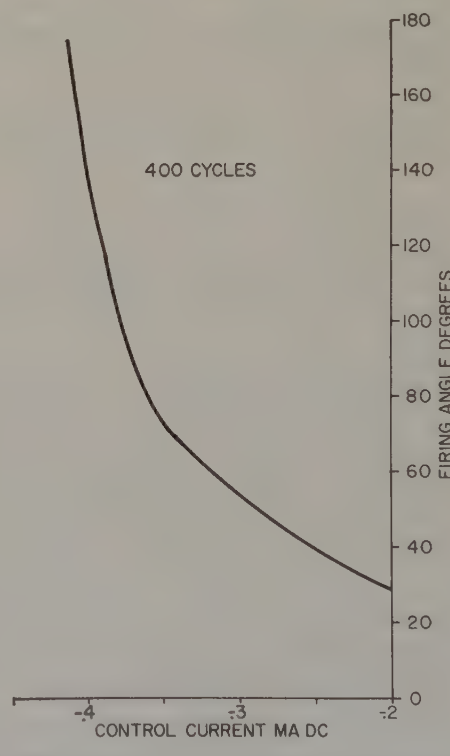

Fig. 10—Firing angle *vs.* single reactor control current. (400 cycle)

The motor transfer function is given by

$$\frac{1}{S}\frac{K}{(JS+B)}\frac{1}{(1+T_2S)} = KG_m$$

where J_s is inertia of the driven system

B is the damping factor

T_2 is the electrical time constant of the rotor

K is the motor gain.

S is the Laplace operator

KG_m can be written also as

$$\frac{\omega_o}{S}\frac{\omega_1}{(S+\omega_1)}\frac{\omega_2}{(S+\omega_2)} = KG_m$$

ω_2 is about four octaves above ω_1, and will be neglected in preliminary design where

$$\omega_2 = \frac{1}{T_2}\ ;\ \omega_1 = B/J\ ;\ \omega_o = K/B$$

The motor considered has the following parameters — Theoretical acceleration — 25, 300 rad/sec.^{2}

Inertia $J = 0.58$ oz-in.$^2 = 0.78 \times 10^{-5}$ *Slug-ft.*^{2}

Synchronous speed $= \dfrac{2\,\pi\,1800}{60} = 60\,\pi$

With rated voltage the torque around stall $= 37.5$ oz.-in. $= 196 \times 10^{-3}$ ft.-lb.

$$B = \frac{196 \times 10^{-3}}{60\,\pi} = 1.04 \times 10^{-3}\left(\frac{\text{ft.-lb.}}{\text{Rad}}\right)$$

$$T_1 = J/B = 0.75 \times 10^{-2} = 7.5 \text{ milliseconds}$$

$$\omega = \frac{1}{T_1} = 133 \qquad f = 21 \text{ cycles}$$

The input impedance of the servo motor is largely inductive. This impedance shifts with operating conditions and input voltage. The motor develops back *emf* with rotation. The back *emf* is responsible for the major portion of the impedance change which makes it inadvisable to try to closely match the amplifier impedance with the motor impedance.

Control Rectifiers for Servo Motor Drive

An amplifier having a variable output voltage and suitable for an *a-c* servo motor drive can be designed using control rectifiers. Such an amplifier may have half wave, full wave single phase *a-c* output or three-phase *a-c* output. A schematic of a full wave *a-c* servo motor variable speed drive is shown in *Fig. 12*.

The silicon controlled rectifiers are driven by the magnetic reset control described previously. Transformer *T1* provides the necessary sequence and combinations of voltages required for the firing and control of the self-saturating reactors *L1A* and *L1B*. The controlled rectifiers *CR1A* and *CR1B* are connected back to back to form a full wave, single phase *a-c* amplifier.

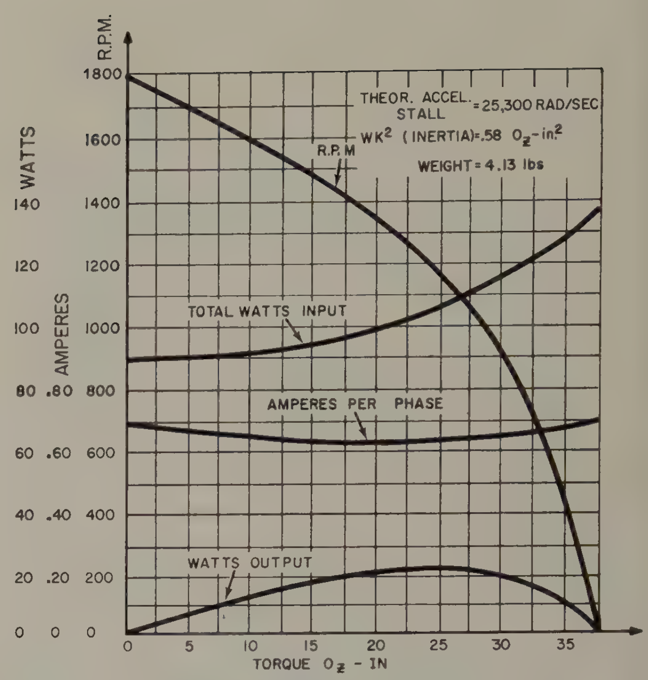

Fig. 11—Typical performance data for *a-c* low inertia servo motor. 16 watts output, 115/115 *v*., 60 cycle, 4 pole, 2 phase.

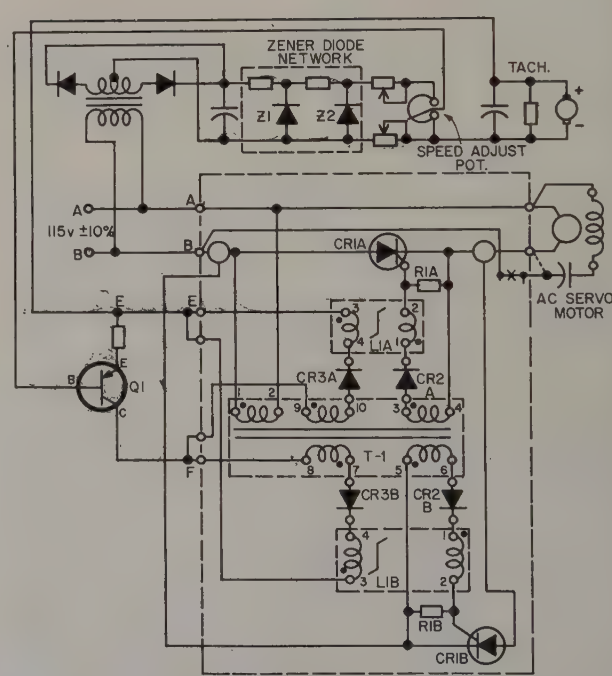

Fig. 12—A-C servo motor speed control. If connected as shown by the dotted lines, the full input to the motor is controlled and no idling losses are incurred.

A signal proportional to the speed is obtained from the tachometer. The tachometer signal is compared with a stable reference signal provided by a zener diode network. The error signal, which is the difference between tachometer signal and reference signal, drives the transistor preamplifier (Q1), which controls the firing angle of the reactors and final control rectifiers. By changing the setting of the speed adjusting potentiometer, the operating point can be varied from standstill to rated speed. The system shown in *Fig. 12* is a representative one. The detecting can be done by various other means such as an *a-c* tachometer, resonant circuits (when a motor driving an *a-c* generator is controlled), pick up pulsing coil with integrator, *d-c* motor armature voltage, etc.

The top of *Fig. 13* shows oscillograms of the amplifier output voltages as they appear across the motor controlled phase.

Fig. 13—Oscillogram taken across controlled phase (top); Trigger output (bottom).

Junction Transistor Measurements And Practical Standards

BERNARD REICH* WILLIAM ORLOFF*

Part 2.

Measurements and circuits required for the specification and evaluation of junction transistors have been set forth. The report covers the basic measurements required on most transistors, and specific techniques and circuits for *vhf* and *uhf* devices.

Base Spreading Resistance — r_b'

Another important transistor parameter is the base spreading resistance r_b'. Its measurement consists essentially of the measurement of the real part of the high frequency input impedance of a common emitter circuit as shown in *Fig. 8*. The equation for impedance looking into the high and low terminals is

$$Z_{in} = r_b' + \frac{Z_e}{1-\alpha} \quad (5)$$

Assuming that at the frequency of measurement, which in this case is 250 mc/sec,

$$\frac{Z_e}{1-\alpha} < r_b' \quad \text{then} \quad (6)$$

$$r_b' \cong R_e\,(Z_{in})$$

The 1.5-30 μμf variable capacitor is placed in series with the base lead to resonate with the lead inductance of the device. r_b' can then be read directly from the R_p dial of an R_x meter.

Junction Capacitances

Of importance in the higher frequency characterization of transistors is the collector depletion layer capacitance and the emitter transition capacitance. The more familiar capacitance, at least the one simpler to measure, is the one associated with the collector de-

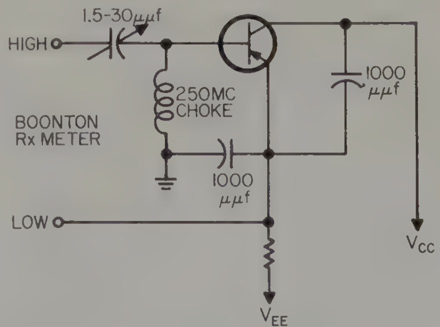

Fig. 8—Measurement of base spreading resistance r_b'.

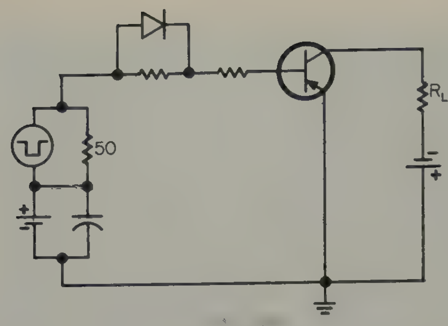

Fig. 9—Circuit used for measurement of rise, storage and fall times.

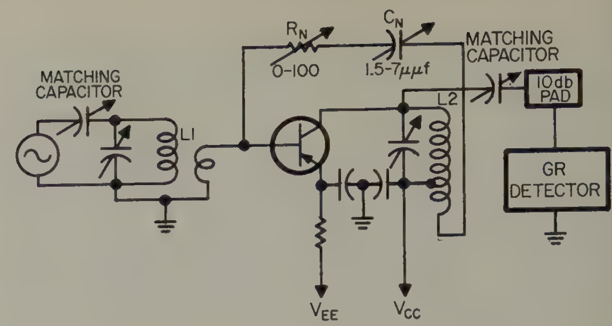

Fig. 10—Circuit for measuring small signal neutralized common emitter power gain covering a frequency range from 30 mc to 200 mc with common base biasing.

pletion layer. In practice the collector depletion capacitance is obtained by measuring the output collector to base capacitance. At this Laboratory this is accomplished by a Kay Lab Dynamic Micro-Miker at a frequency of 1 megacycle per second. Subtracting this measured capacitance from the header capacitance yields the collector depletion layer capacitance C_C.

The measurement of the emitter transition capacitance is not made directly but is arrived at by plotting $1/f_T$ as a function of $1/I_E$. The details of this measurement technique and subsequent analysis is beyond the scope of this article. It must be said, however, that this parameter is of importance in switching devices.

Significance of *VHF* and *UHF* Parametric Measurements

Ideally, from the information presented in the preceding portions of this paper, the prediction of the transistor circuit performance should be calculable. For the instant, we assume this to be the case and examine the significance of the parameters previously discussed. A figure of merit most commonly used in the discussion of transistors is the maximum frequency of oscillation. In terms of the parameters previously discussed, f_{max} is expressed as follows:

$$f_{max} = \frac{h_{fb} \times f_{cb}}{8\pi r_b'} \qquad (7)$$

where h_{fb} is the low frequency current gain and f_{cb} is the alpha cut-off frequency.

If the f_{cb} x h_{fb} product approximates the f_T frequency then

$$f_{max} = \frac{f_T}{8\pi r_b' C_c} \qquad (8)$$

The parameters previously discussed namely f_T, r_b, and C_c can now be used to predict the performance of transistors in circuit applications. If f_{max} is known, the matched, neutralized power gain of a tuned amplifier can be predicted. From f_{max} the power gain will increase at a rate of 6 *db*/octave for most transistors. The performance of transistor oscillators can also be predicted from f_{max}. In the article by Thornton and Angell[5] values of fall of oscillator efficiency with frequency of 25% per octave for the *sbt* and 23% per octave for the *madt* have been shown. These figures have been corroborated by the authors for the *madt* and other diffused and graded base structures. The importance of f_{max} as a useable figure of merit cannot be overemphasized.

To further demonstrate the importance of these device parameters we examine the equation for the rise time of a highly saturated *madt* transistor and find that:[6]

$$t_r = \frac{0.8\, h_{fec}}{2\pi f_T} \qquad (9)$$

where h_{fec} is the common emitter circuit gain.

Similarly for fall time

$$t_f = \frac{0.8\, h_{feco}}{2\pi f_T} K_L \qquad (10)$$

where h_{feco} is the turn-off circuit gain, and

$$K_L = (1 + 2\pi f_T R_L C_c)$$

where R_L is the load resistor and C_c is the collector capacitance.

$$K_L = (1 + 2\pi f_T R_L C_c)$$

Functional Transistor Measurements

Unfortunately for both the manufacturer of devices and the consumer, it has not been possible to adequately specify transistor performance in terms of its parameters. To both parties this means added cost since the use of functional transistor measurements becomes necessary. Functional measurements, although alleviating a specific problem, are not universal, in that the functional measurement made covers a specific circuit condition under specified set bias conditions. With this cautioned introduction we can now discuss some of the functional measurements made on military devices.

A circuit commonly used for the measurement of transistor switching speed is shown in *Fig. 9*. In this particular circuit current turn-on and turn-off are employed. The circuit is normally off and is turned on by the application of a pulse $-V$ applied to the tran-

Schweber

BUYERS AND ENGINEERS GUIDE TO

FAIRCHILD
SEMICONDUCTOR CORPORATION

TRANSISTORS

This is an engineering sheet removable for ready reference

FAIRCHILD DIFFUSED SILICON MESA TRANSISTORS

Where applications require transistor performance beyond previously accepted high limits, Fairchild Silicon Transistors offer an exceptional 5-way combination:

SPEED
80 milli-micro-second rise time affords the fastest switching yet available with silicon.

POWER
2 watts dissipation at 25°C. leaves plenty of power handling capacity at higher temperatures.

RELIABILITY
Storage at 300°C. for 350 hours caused no serious changes, assuring a large safety factor at operating temperatures.
Mesa construction provides extraordinary ruggedness too.

AVAILABILITY
Quantities 1 to 1,000, from stock for same day shipment, available at Schweber Electronics.

PRICE
Gearing for quantity sales has brought prices down within reach of more users.
Schweber's price? Factory price, of course!

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1st FOR TRANSISTORS

ABSOLUTE MAXIMUM RATINGS (25° C.) [Note 1]

V_{CBO}	—	Collector to base voltage
V_{EBO}	—	Emitter to base voltage
V_{CER}	—	Collector to emitter voltage

Total dissipation at case temperature 25° C. [Note 3]
at case temperature 100° C.
at free air temperature 25° C.

MULTI-PURPOSE NPN—2N696, 2N697

Multi-purpose silicon mesa units for amplifier, switching and medium power applications. The inherent high speed switching characterist make them the most advanced transistors available.

Gain-bandwidth product is typically 80 megacycles on 2N696 and 100 megacycles on 2N697.

A superior combination of speed, power and reliability.

2N696

SYMBOL	CHARACTERISTIC	MIN.	TYPICAL	MAX.	TEST CONDITION	
h_{FE}	D. C. pulse current gain [Note 4]	20	40	60	I_C=150mA	V_C=1
$V_{BE\ SAT.}$	Base saturation voltage		1.0V	1.3V	I_C=150mA	I_B=1
$V_{CE\ SAT.}$	Collector saturation voltage		0.7V	1.5V	I_C=150mA	I_B=1
h_{fe}	Small signal current gain at f = 20mc	2	4		I_C= 50mA	V_C=1
C_{ob}	Collector capacitance		20μμf	35μμf	I_E= 0mA	V_C=1
I_{CBO}	Collector cutoff current		.01μA 5μA	1.0μA 100μA	V_C= 30V V_C= 30V	T= T=1

2N697

SYMBOL	CHARACTERISTIC	MIN.	TYPICAL	MAX.	TEST CONDITIONS	
h_{FE}	D. C. pulse current gain [Note 4]	40	75	120	I_C=150mA	V_C=10
$V_{BE\ SAT.}$	Base saturation voltage		1.0V	1.3V	I_C=150mA	I_B=15
$V_{CE\ SAT.}$	Collector saturation voltage		0.7V	1.5V	I_C=150mA	I_B=15
h_{fe}	Small signal current gain at f = 20mc	2.5	5		I_C= 50mA	V_C=10
C_{ob}	Collector capacitance		20μμf	35μμf	I_E= 0mA	V_C=10
I_{CBO}	Collector cutoff current		.01μA 5μA	1.0μA 100μA	V_C= 30V V_C= 30V	T= 2 T=15

HIGH VOLTAGE NPN—2N699

The unique combination of characteristics in the 2N699 offers performances previously unattainable.

Greater voltage swing in oscillator and amplifier circuits, more production in inductive switching circuits due to the 120 volts collector to base voltage rating plus no sacrifice in speed or pow characteristics make this transistor a most important addition to the Fairchild family of silicon mesa transistors.

Its applications range from low-current high-frequency I-F circuits to high-current, low-frequency relay drivers.

2N699

SYMBOL	CHARACTERISTIC	MIN.	TYPICAL	MAX.	TEST CONDITION	
h_{FE}	D. C. pulse current gain [Note 4]	40		120	I_C=150mA	V_C=1
$V_{BE\ SAT.}$	Base saturation voltage		0.95V	1.3V	I_C=150mA	I_B=1
$V_{CE\ SAT.}$	Collector saturation voltage		2.0V	5V	I_C=150mA	I_B=1
h_{fe}	Small signal current gain at f = 20mc	2.5	5		I_C= 50mA	V_C=1
C_{ob}	Collector capacitance		14μμf	20μμf	I_E= 0mA	V_C=1
I_{CBO}	Collector cutoff current		.01μA 3μA	2μA 200μA	V_C= 60V V_C= 60V	T= T=1

NOTES: 1. The maximum ratings are limiting absolute values above which life or satisfactory performance may be impaired. 2. Ra where

	NPN							PNP	
	2N696	2N697	2N699	2N706	2N1252	2N1253	2N1420	2N1131	2N1132
	60v	60v	120v	25v	30v	30v	60v	−40v	−40v
	5v	5v	5v	3v	5v	5v	5v	−5v	−5v
	40v	40v	80v	20v	20v	20v	30v	−30v	−30v
	2 watts	2 watts	2 watts	0.6 watt	2 watts	2 watts	2 watts	2 watts	2 watts
	1 watt	1 watt	1 watt	0.3 watt	1 watt	1 watt	1 watt	1 watt	1 watt
	0.6 watt	0.6 watt	0.6 watt	0.3 watt	0.6 watt	0.6 watt	0.6 watt	0.6 watt	0.6 watt

ULTRA FAST SWITCH NPN—2N706

The 2N706 is as fast as the fastest germanium. Because of its inherent low storage, overdrive ceases to be a speed-limiting factor. No diodes or other components are needed to keep it out of saturation.

10 megacycle clock rates with low current (5 milliamps) saturated logic circuit are obtainable reliably for the first time. Packaged in the JETEC (TO-18) header, the 2N706 permits high density building block computer packaging techniques to be employed.

2N706

SYMBOL	CHARACTERISTIC	MIN.	TYPICAL	MAX.	TEST CONDITIONS	
h_{FE}	D. C. pulse current gain [Note 4]	15			I_C = 10mA	V_C = 1.0V
$V_{BE\ SAT}$	Base saturation voltage		0.75V	0.9V	I_C = 10mA	I_B = 1mA
$V_{CE\ SAT}$	Collector saturation voltage		0.3V	0.6V	I_C = 10mA	I_B = 1mA
h_{fe}	Small signal current gain at f 100mc		4		I_C = 10mA	V_C = 15V
C_{ob}	Collector capacitance		5μμf	6μμf	I_E = 0mA	V_C = 10V
I_{CBO}	Collector cutoff current		.005μA 3.5μA	0.5μA 30μA	V_C = 15V V_C = 15V	T = 25° C. T = 150° C.
$\bar{t}_{pd}$	DCTL Propagation Delay (See chart and definition on page 3.)		5–11mμs Mean—8mμs		I_C = 4.5mA	T = 25°C

LOW STORAGE NPN—2N1252, 2N1253

Low storage time and low saturation voltage make the 2N1252 and the 2N1253 ideal for all types of saturated circuitry from low logic levels to 1/2 ampere core driving levels. These units make 5 megacycle saturating switching circuits possible.

A few of the many applications are magnetic core drivers, drum and tape write drivers, high-current pulse generators and clock amplifiers.

2N1252

SYMBOL	CHARACTERISTIC	MIN.	TYPICAL	MAX.	TEST CONDITIONS	
h_{FE}	D. C. pulse current gain [Note 4]	15	35	45	I_C = 150mA	V_C = 10V
$V_{BE\ SAT.}$	Base saturation voltage		0.9V	1.3V	I_C = 150mA	I_B = 15mA
$V_{CE\ SAT.}$	Collector saturation voltage		0.6V	1.5V	I_C = 150mA	I_B = 15mA
h_{fe}	Small signal current gain at f = 20mc		4		I_C = 50mA	V_C = 10V
C_{ob}	Collector capacitance		30μμf	45μμf	I_E = 0mA	V_C = 10V
I_{CBO}	Collector cutoff current		0.1μA 100μA	10μA 600μA	V_C = 20V V_C = 20V	T = 25° C. T = 150° C.
t_s+t_f	Turn off time		75mμs	150mμs	I_C = 150mA I_{B2} = 5mA Pulse width = 10 ms	I_{B1} = 15mA R_L = 40Ω

2N1253

SYMBOL	CHARACTERISTIC	MIN.	TYPICAL	MAX.	TEST CONDITIONS	
h_{FE}	D. C. pulse current gain [Note 4]	30	45	90	I_C 150mA	V_C = 10V
$V_{BE\ SAT.}$	Base saturation voltage		0.9V	1.3V	I_C = 150mA	I_B 15mA
$V_{CE\ SAT.}$	Collector saturation voltage		0.6V	1.5V	I_C = 150mA	I_B = 15mA
h_{fe}	Small signal current gain at f = 20mc	2.5	5.5		I_C 50mA	V_C = 10V
C_{ob}	Collector capacitance		30μμf	45μμf	I_E = 0mA	V_C - 10V
I_{CBO}	Collector cutoff current		0.1μA 100μA	10μA 600μA	V_C 20V V_C 20V	T = 25° C. T = 150° C.
t_s+t_f	Turn-off time		75mμs	150mμs	I_C = 150mA I_{B2} = 5mA Pulse width = 10 ms	I_{B1} = 10mA R_L = 40Ω

ELECTRICAL CHARACTERISTICS (25° C.)

STANDARD PNP—2N1131, 2N1132

The circuit designer need no longer be limited by unavailability of PNP transistors.

Schweber has them in stock.

These transistors closely match the Fairchild 2N696 and 2N697 respectively, making possible high speed circuits with complementary symmetry and affording choice of polarity in any appropriate application.

2N1131

SYMBOL	CHARACTERISTIC	MIN.	TYPICAL	MAX.	TEST CONDITIONS	
h_{FE}	D. C. pulse current gain [Note 4]	15		45	I_C = 150mA	V_C = −10V
$V_{BE\ SAT.}$	Base saturation voltage		−1.0V	−1.5V	I_C = 150mA	I_B = −15mA
$V_{CE\ SAT.}$	Collector saturation voltage		−1.0V	−1.5V	I_C = 150mA	I_B = −15mA
h_{fe}	Small signal current gain at f = 20mc		2.5		I_C = 50mA	V_C = −10V
C_{ob}	Collector capacitance		35μμf	45μμf	I_E 0mA	V_C = −10V
I_{CBO}	Collector cutoff current		.01μA 5μA	1.0μA 100μA	V_C = 30V V_C 30V	T = 25° C. T = 150° C.

2N1132

SYMBOL	CHARACTERISTIC	MIN.	TYPICAL	MAX.	TEST CONDITIONS	
h_{FE}	D. C. pulse current gain [Note 4]	30		90	I_C = 150mA	V_C = −10V
$V_{BE\ SAT.}$	Base saturation voltage		−1.0V	−1.5V	I_C = 150mA	I_B = −15mA
$V_{CE\ SAT.}$	Collector saturation voltage		−1.0V	−1.5V	I_C = 150mA	I_B = −15mA
h_{fe}	Small signal current gain at f = 20mc		3		I_C = 50mA	V_C = −10V
C_{ob}	Collector capacitance		35μμf	45μμf	I_E = 0mA	V_C = −10V
I_{CBO}	Collector cutoff current		.01μA 5μA	1.0μA 100μA	V_C = 30V V_C = 30V	T = 25° C. T = 150° C.

HIGH BETA NPN—2N1420

For high beta applications, the 2N1420 provides a minimum beta of 100 and a maximum beta of 300 without sacrifice in speed and power.

These features are combined with the basic characteristics of the NPN 2N696 to make this another reliable and outstanding Fairchild transistor.

2N1420

SYMBOL	CHARACTERISTIC	MIN.	TYPICAL	MAX.	TEST CONDITIONS	
h_{FE}	D. C. pulse current gain [Note 4]	100		300	I_C = 150mA	V_C = 10V
$V_{BE\ SAT.}$	Base saturation voltage		1.0V	1.3V	I_C = 150mA	I_B = 15mA
$V_{CE\ SAT.}$	Collector saturation voltage		0.6V	1.5V	I_C = 150mA	I_B = 15mA
h_{fe}	Small signal current gain at f = 20mc	2.5	6.5		I_C = 50mA	V_C = 10V
C_{ob}	Collector capacitance		20μμf	35μμf	I_E = 10mA	V_C = 10V
I_{CBO}	Collector cutoff current		.01μA 5μA	1.0μA 100μA	V_C = 30V V_C = 30V	T = 25° C. T = 150° C.

...t point ...lowest.

3. These ratings (except 2N706) give a maximum junction temperature of 175°C. and junction-to-case thermal resistance of 75°C./watt (derating factor of 13.3 mw/°C.). For 2N706—junction-to-case thermal resistance of 250°C./watt (derating factor of 4mw/°C.).

4. Pulse conditions: length ≦ 12 ms.; duty cycle ≦ 2%.

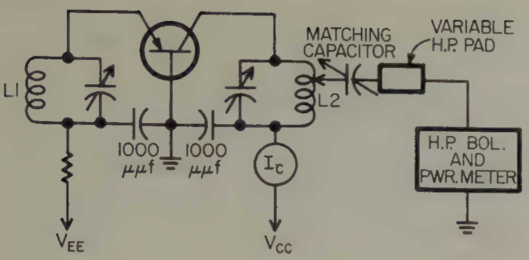

Fig. 11—Circuit for the measurement of oscillator performance in the frequency range from 70 to 400 mc.

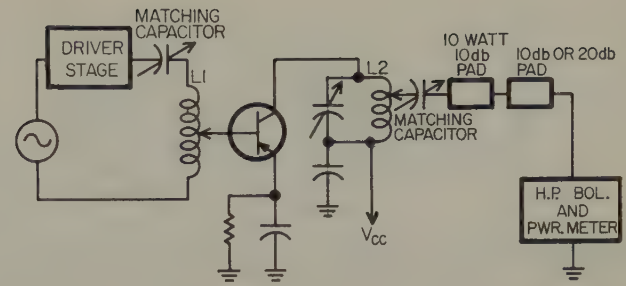

Fig. 12—Circuit for measuring large signal, common emitter, class C power amplifier performance from 70 to 200 mc (100 mw to 10 watts).

sistor base. An oscilloscope of appropriate speed is used to measure the delay, rise, storage and fall times. Although the circuit shown in *Fig. 9* utilizes current turn-on and turn-off, it is possible to use other circuit conditions for this procedure. These varied circuit arrangements necessitate the specification of transistor switching parameters.

One of the more important functional tests is the measurement of power gain of a transistor amplifier intended for *r-f* or *i-f* amplifier use. The measurement of this functional parameter is usually made at the frequency of interest in a common emitter neutralized circuit. *Fig. 10* is the circuit being used at this Laboratory for making this functional measurement. Included are means for matching and tuning both input and output circuits, and for adjusting for optimum neutralization. Reverse power gain from output to input is usually between —50 and —60 *db*. The input and output are tuned and matched to give maximum output for fixed input power. The functional measurement not only yields information at the desired frequency, but also indicates what could be expected at least an octave above and below if the rate of fall-off of power gain with frequency is known. This may be 6 *db*/octave, or may vary with the particular design examined.

Another functional measurement of interest to users may be the performance of the device as a power oscillator in the *vhf* and *uhf* region. *Fig. 11* is the common-base circuit used for evaluating transistors as power oscillators in the 70-400 *mc*/sec range. Provision is made for tuning the input and output of the transistor. Provision is not made, however, for external feedback elements since it has been found unnecessary in most cases. Power is measured with a bolometer, and *d-c* biases are monitored during the course of the measurement. This circuit has been found quite useful in examining the variation of oscillator efficiency with frequency.

Finally, the last functional test to be described is that used in measuring the performance of a transistor as a Class C tuned power amplifier. With the increasing strides made in fabricating transistors with high f_{max} frequencies and good thermal handling capabilities, consideration has been given to using them as power amplifiers in the *vhf* range. Of importance then to the user is the power gain and efficiency he can obtain utilizing transistors as power amplifiers. *Fig. 12* is a circuit used for evaluating transistors as tuned power amplifiers.

Up to this point in the article we have not discussed transistor noise figures and purposely so. Only a few short comments concerning the noise figure problem are deemed necessary. It is necessary to determine the transistor noise figure not only at a low frequency where the 1/*f* noise may predominate but actually at higher frequencies where the device is intended for application. Ideally a curve of the variation of noise figure, with frequency and bias point, should be presented.

Transistor Reliability Testing

Our discussion of transistor reliability testing in this article does not concern itself with the associated statistics. We will, however, discuss the problems associated with arriving at a meaningful life test.

Generally there are two methods of determining how well transistors sustain operation under conditions differing from the normal room temperature aging. These are commonly referred to as "storage" and "operating" life testing. Both the "storage" and "operating" life tests are conducted for a 1000 hour period with allowable limits of change specified for the device.

Current practices require that the "storage" life test be run on germanium devices at +85°C or +100° C. For silicon devices, the temperature range is usually +150°C to +200°C. This type of test is straightforward, and does not require an unusual amount of apparatus. During the course of this test certain key parameters are measured. These are usually collector cut-off current, emitter cut-off current, and current gain.

"Operating" life tests may have many forms. The most common is the *d-c* operating life test run at a particular bias on a continuous basis. Another type of test similar to the one just described is the intermittent type test where *d-c* bias is applied for a speci-

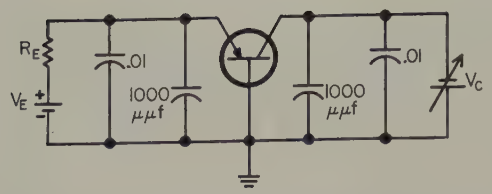

Fig. 13—Circuit for measuring operational life-testing.

fied time, for example 50 minutes out of each hour. In addition more complicated life tests can be run such as switching tests where the transistor is periodically switched from a high voltage low current condition to a high current low voltage condition. Finally, functional life tests can be run wherein the transistor is placed in a circuit simulating operating conditions.

The question that arises with operating life tests is which test most accurately simulates circuit operation. For example suppose an *r-f* transistor is designed to operate at an optimum performance level when biased at 10*v* and 2 *ma*. The power handling capability of the device is 100 *mw* at 25°C. Are we justified in running a life test at 10*v* and 10 *ma* or 5*v* and 20 *ma* or combinations multiplying out to 100 *mw*? In writing a specification for general usage, it is difficult to choose a suitable life test and a life test ambient condition which is representative of general applications. Furthermore what does this life test under the most stringent conditions tell the circuit designer when he is considering operating his device below the extreme?

The problems that have been raised in the previous paragraphs have not been solved. What must be done to solve them, however, is to determine the factors governing the life of transistors. Is it junction temperature, collector voltage, or a combination of these factors? Is a storage life test the best, simplest, and adequate to run? What is the failure rate of transistors as a function of temperature? These questions must be answered before one is able to choose the most suitable life test.

Before leaving the subject of life testing some subtle remarks are in order concerning the circuitry used in life testing *vhf* and *uhf* transistors. The problem that is often overlooked in life testing is the parasitic oscillations that may occur in the life testing of these devices. These devices may oscillate either at low or high frequencies depending on the conditions external to the device such as wiring. Therefore, the circuit of *Fig. 13* should be used when higher frequency devices are being operationally life tested.

Conclusions

An attempt has been made to set down the present measurement techniques used to evaluate transistor parameters and in addition to discuss some of the problem areas. It is hoped that the circuit designer will get a better appreciation for the problem that the device specifier has in measuring and rating his product.

Acknowledgement

Acknowledgement is made of the efforts of our colleagues in the Circuit Functions Branch, Solid State Devices Division, for supplying basic information and circuitry which was very helpful in the preparation of this article.

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(4) Crosby, Jr., Lin & Re, "Determination of Themal Resistance of Si Junction Devices," *IRE Natl. Convention Record. Part 3, Vol. 6.*

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Errata

The following corrections to the article "14 Inch Direct View Transistorized Television Receiver" which appeared in the Dec. 1959 issue, are to be noted.

In the "Video Driver" discussion on page 25, there are two references to a 4.7K resistor. In each case the value should be 3.3K instead of 4.7K.

In *Fig. 12* on page 28, the cathode of the 1N152 damper diode should be connected to +12 volts and not to ground as shown.

Multiple-Interval Timers Using Gated Staircase Counters

T. R. HOFFMAN*

Staircase counters using single crystal barium titanate capacitors were described in an article which appeared in the November 1959 issue of *Semiconductor Products*. Such counters can be gated on or off by means of switching transistors, hence two or more counters can be used to time two or more independent intervals sequentially. The gating sequence is controlled by a combination of flip-flops and simple logic circuits. An analog-to-digital converter using the gated counter principle is discussed briefly.

A STAIRCASE COUNTER is a circuit in which the voltage across a linear capacitor C (Refer to *Fig. 1.*) is increased in steps until a critical level is reached, at which point C is discharged, thereby resetting the counter. The step-charging process then repeats itself. The "count ratio" of such a circuit is defined as the number of steps required to reach the critical level. Stated another way, it is the number of input events required to produce a single output. If the input is periodic, it is simply the frequency division ratio.

Counters of the staircase type that utilize single-crystal barium titanate capacitors to "meter" the charge increments to C were previously described in detail.[1] *Fig. 1* shows the circuit diagram. The single-crystal capacitor SC has the charge versus voltage characteristic (or "hysteresigram") of *Fig. 2.*

Whenever the input goes positive, SC is switched from B to A on the hysteresigram, and an amount of charge $2Q_R$ is "dumped" into linear capacitor C via diode D_1. When the input next goes negative, SC is reset to B via diode D_2 without affecting the charge and hence voltage, on C. Subsequent positive input excursions will each add a voltage step $2Q_R/C$ to C until the critical level of the discharge device is reached. *Fig. 3* shows the waveforms for a count ratio of 4, assuming sinusoidal input. The discharge device is a silicon unijunction transistor. Each time it conducts a negative voltage spike is generated at base $B2$ as shown.

In this article a method for independently timing two sequential intervals with counters of this type is presented. This method then is extrapolated to include the possibility of timing any number of sequential intervals. An analog-to-digital converter using the same principle also is described.

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Gating The Staircase Counter

The circuits to be considered in the ensuing paragraphs extend the versatility of the basic counter by the inclusion of a gating feature. That is, they can be prevented from counting even though the input is still

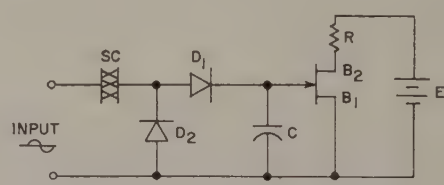

Fig. 1—Staircase counter.

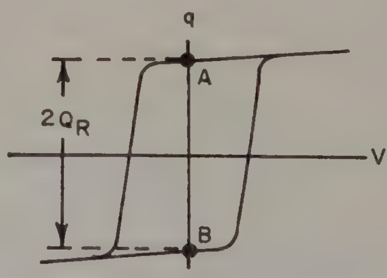

Fig. 2—Charge versus voltage for single-crystal capacitor.

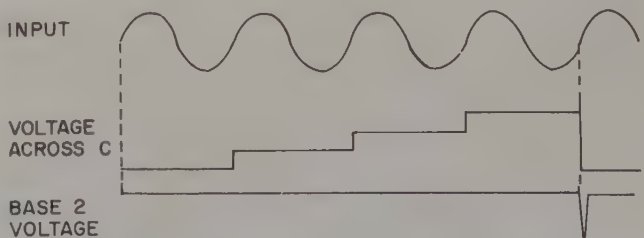

Fig. 3—Staircase counter waveforms.

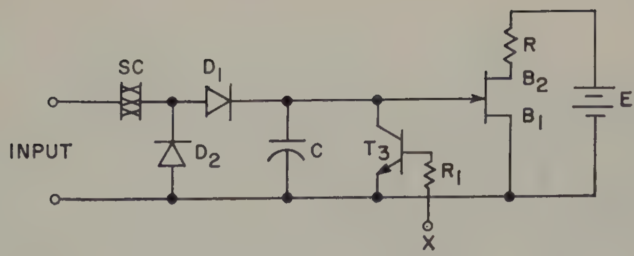

Fig. 4—Gated staircase counter.

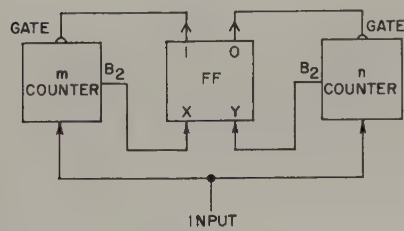

Fig. 5—Two-interval timer block diagram.

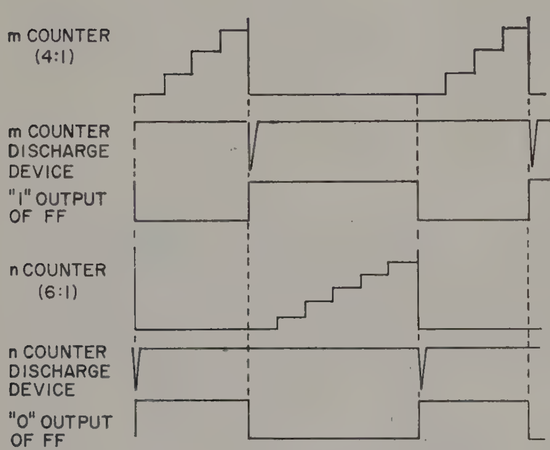

Fig. 6—Two-interval timer waveforms.

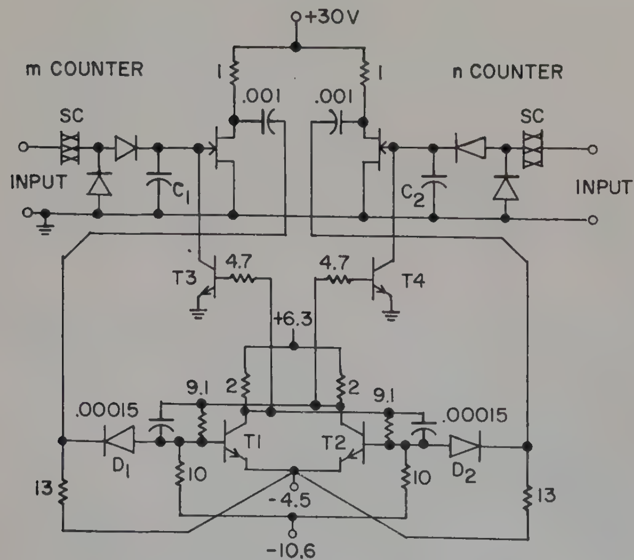

Fig. 7—Two-interval timer schematics.

applied. *Fig. 4* shows the means for doing this. *N-P-N* gating transistor *T3* is connected directly across the capacitor on which the charge increments normally accumulate. If *T3* is turned off by means of a negative voltage at point *X*, it is essentially an open circuit, and counting continues as in *Fig. 1*. If, however, *T3* is turned on by supplying a positive voltage at *X*, *C* is shunted by a very low resistance so that charge cannot accumulate on it. Approximately, then, *T3* operates as a switch. When closed, it shorts *C* out, but when open it allows normal counting. The detailed behavior of transistors as switches has been covered by Ebers and Moll.[2] Suffice it to say here, that transistors designed specifically for switching applications (such as the 2N634) perform satisfactorily in this respect.

A Two-Internal Timer Using Gated Counters

To time two intervals independently, two of the basic counters were used. Each was equipped with a gating transistor, as described previously under "Gating the Staircase Counter." The gates were controlled by a bistable transistor pair (or "flip-flop") connected in such a way that one, but not both, of the gates was always open.

The block diagram is shown in *Fig. 5*. The two counters employ the circuit of *Fig. 1*, using 2N490 unijunction transistors as the discharge device. *FF* denotes the bistable flip-flop. A negative trigger at "X" will produce a positive output level at "1" and a negative output level at "0", whereas a negative trigger at "Y" will have the opposite effect. Each gate is so arranged that when its input is positive it "inhibits" (i.e., prevents operation of) its counter.

The sequence of events can best be illustrated by the series of waveforms shown in *Fig. 6*. The *m* counter is enabled first and counts a number of input cycles dictated by the value of its linear capacitor. When the *m* unijunction transistor "fires", a negative pulse appears at its base 2 terminal. This pulse sets *FF* so that "1" is positive and "0" negative, as previously mentioned. The positive level at "1" closes the *m* gate, thereby disabling the *m* counter. The negative level at "0" simultaneously enables the *n* counter, which therefore counts a number of input cycles dictated by its linear capacitor. At the end of the *n* count conduction of the *n* unijunction transistor reverses the *FF* levels, enabling the *m* and disabling the *n* counter. The sequence just described repeats until manually turned off.

Fig. 7 shows the complete schematic diagram. The transistor flip-flop uses 2N634 *n-p-n* germanium transistors. Triggering is effected by applying a negative pulse to the conducting base via a silicon diode (D_1 or D_2). The gating functions are performed by 2N634 transistors T_3 and T_4 shunting the counter linear capacitors C_1 and C_2. When the gate transistor is "on" (i. e., a closed switch) the linear capacitor is effectively shorted out; hence, no charge can build up on

it. When the transistor is "off" (i.e., an open switch), the linear capacitor is shunted only by the very high "off" resistance of the transistor and normal counting takes place.

Independent variation of C_1 and C_2 can vary the duration of the two intervals as desired. *Fig. 6* shows the case where the *m* count is 4 cycles and the *n* count 6 cycles. Each count can be varied from small integers to 100 or more by varying *C*—the range is that of a single counter. There is no interaction.

Extension Of The Principle To Any Number Of Independent Intervals

To extend the principle of a two-interval timer using gated counters to any number of independent intervals, it is necessary to use one gated counter per interval and to provide a gate control having a number of states equal to the desired number of intervals. For example, two flip-flops together comprise a 4-state system (i. e.—both "0," both "1," and two possibilities for one "1," one "0"). Simple logic circuits can then be used to sense the state of the flip-flops and enable the appropriate counter. *Fig. 8* shows a block diagram of a system for controlling four independent sequential intervals.

Every negative trigger to FF_B from any one of the counters will flip *B* from one of its states to the other. FF_A is connected to FF_B in such a way that it will be flipped from one of its states to the other only when FF_B goes from "1" to "0." (This is a common interconnection for flip-flop counter chains. The state of the flip-flops at any instant indicates in binary form the number of triggers received since the last time they were both "0.")

Each of the four possible states of FF_A and FF_B (considered together) will enable one, and only one, of the counters. The table below shows the correspondence:

FF_A	FF_B	Counter Enabled
0	0	m
0	1	n
1	0	p
1	1	q

The counters will thus count in sequence—with the count ratio of each determined by its linear capacitor *C* (or by its unijunction transistor E_{bb}, if desired). The firing of any one of the unijunction transistors will send a negative trigger to FF_B, which will advance the $FF_A - FF_B$ combination to its next state. *Fig. 9* shows a sequence in which *m, n, p* and *q* have count ratios of 3, 5, 7 and 9, respectively.

An Analog-To-Digital Converter

A voltage-input analog-to-digital converter must perform the function indicated in *Fig. 10*. One approach is to cause the analog voltage to gate a number of constant-amplitude uniformly spaced "clock" pulses directly proportional to itself. *Fig. 11* shows the gated pulses for two values of analog voltage. The

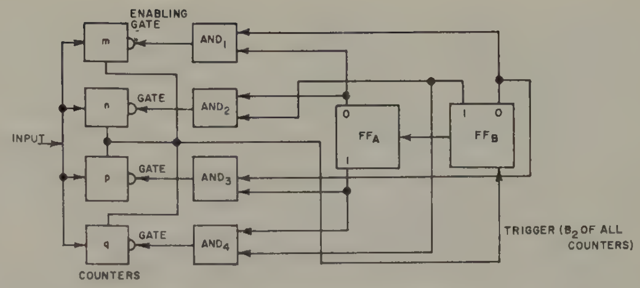

Fig. 8—Four interval timers.

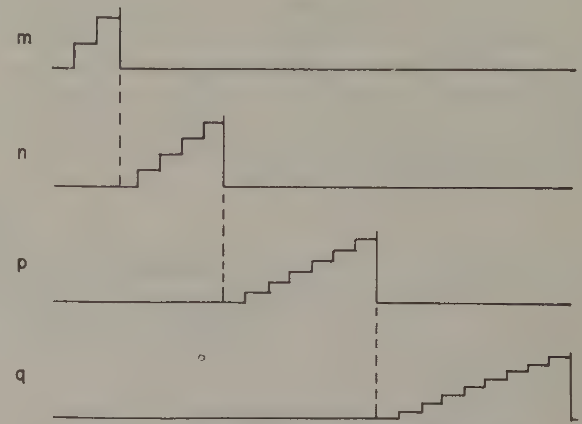

Fig. 9—Four-interval timer waveforms.

Fig. 10—Analog-to-digital conversion.

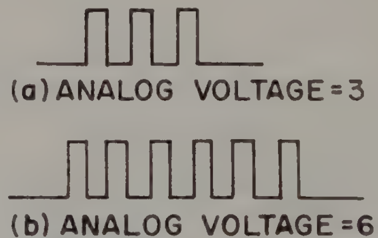

Fig. 11—Gated pulse trains.

number of pulses is a measure of the quantity to be converted. These pulse trains, fed into a flip-flop register previously reset to 0, will set the register to the appropriate digital number.

A gated counter of the type discussed previously can be used to control the register in the manner described. *Fig. 12* shows the block diagram. The analog voltage serves as the E_{bb} of the counter unijunction transistor; hence, the count ratio is directly pro-

portional to the analog level. When the unijunction transistor conducts and discharges the counter linear capacitor, FF_1 flips and disables the counter until the next pulse at the terminal marked "start." The staircase waveform generated by the counter will appear as in *Fig. 6*. Differentiation of this waveform (with diode suppression of the negative peak) will produce a string of positive spikes to set the register.

If the conversion is to be made repeatedly (as would normally be the case), FF_1 could be a one-shot multivibrator that gates the counter off for a specified interval to allow for register read-out, then resets the register for the next count.

One possible inconvenience lies in the fact that E_{bb} must be positive at all times for correct operation of the counter. If the analog voltage inherently can have either polarity, it would be necessary to add a constant *d-c* bias to keep the net unijunction transistor base 2 voltage always positive.

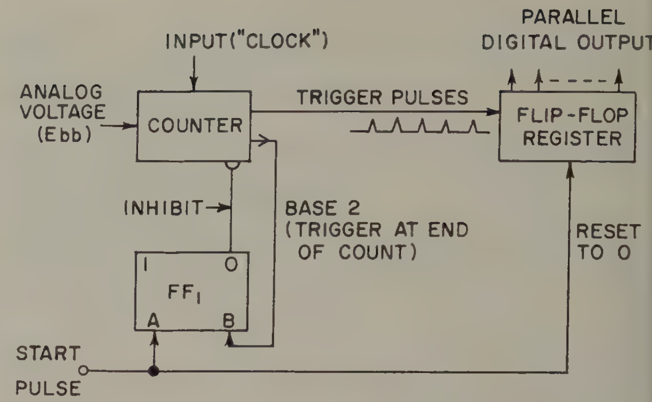

Fig. 12—Converter block diagram.

An advantage occasioned by the use of the single-crystal capacitor counter is that the "clock" can be a sine wave, rather than pulses as shown.

References

(1) "Counters using Single Crystal Bariom Titanate Capacitors" by T. R. Hoffman *Semiconductor Products,* November 1959.

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Solid State Power Inversion Techniques

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An example of harmonic commutation[8] is shown in *Fig. 7A*. This method of commutation operates over the full 360 degree in *Fig. 4A* and reduces the amount of condenser *kva* (which is also at higher frequency) required in a given circuit to get a given commutating angle. The inductance in series with the capacitor causes the wave shape during commutation to be less acute.

Fig. 8 shows the voltage waves for phases "A" and "B" with a 25 percent third harmonic superimposed. At the instant t_1, the voltage e_1 is greater than e_2 and therefore commutation can be effected even when the current wave lags the voltage. Therefore, by distorting the voltage wave by a superimposed harmonic, the instantaneous value of the difference of phase voltages may be such as to produce the proper commutation, even in the lagging quadrant. This method of producing commutation has been called harmonic commutation because it employs some harmonic of the fundamental voltage to force the commutation.

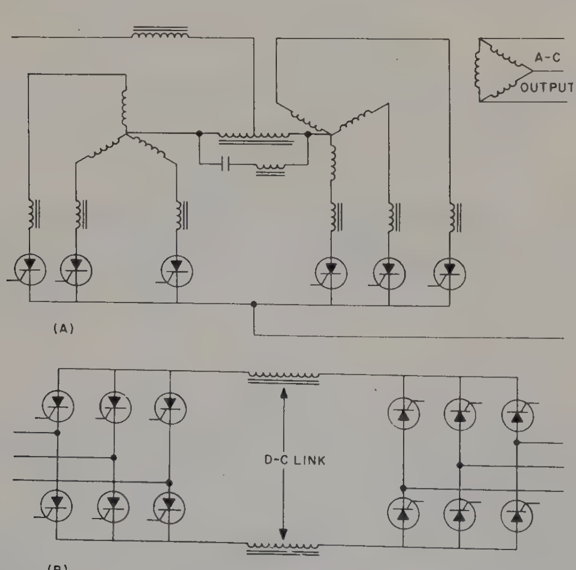

Fig. 7—(A) Circuit using harmonic commutation mode of operation. (B) Circuit using phase commutation mode of operation.

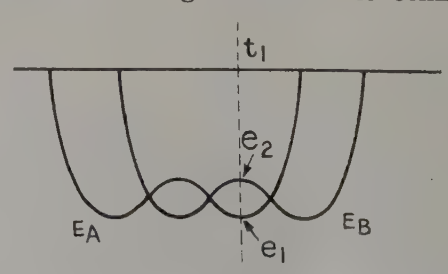

Fig. 8—Harmonic commutation.

Such commutation seems to be quite closely analogous to interpole commutation in direct-current machines.

There are two general methods in which harmonic commutation can be applied:

1. By introducing the harmonic voltage into the circuit through the main transformers.
2. By employing a separate harmonic or commutating transformer.

Harmonic commutation becomes more favorable with an increase in the number of phases. If it is assumed that the rating of a given piece of equipment may be increased proportionately with the frequency, then the cost of harmonic commutation will vary more rapidly than inversely as the square of the number of phases. With six phases and unity power-factor, harmonic commutation will require the equivalent of about 20 percent additional equipment. However, with 12 phases this has been reduced to about 3 percent.

Harmonic commutation using a single-phase inverter to produce the commutating voltage has the following advantages:

1. There is no increased voltage impressed upon the continuous-current choke.
2. The commutating time may be made as long as the conducting period.
3. There is no danger of insufficient commutating voltage at light loads.

Often the application requirement calls for a fixed change in frequency which can be accomplished with a frequency changer. Circuits to be discussed in this category change frequency directly and do not first require rectification to produce *d-c*. Also the problems associated with load transients and power factor changes are reduced as compared to parallel and series commutated inverters. A multiplier circuit is shown in *Fig. 9A*. This circuit uses the high ripple of a phase controlled rectifier (phase commutation) as a usable output with the output *d-c* approaching zero. These approaches penalize the input *a-c* power factor wise in producing the *a-c* harmonic directly. Of course, other harmonics can be obtained with other circuits and device connections.

The circuit of *Fig. 9B* is an example of one of many divider or frequency commutated circuits. The output is composed of a number of fundamental pulses determined by the control circuit. The power factor of the circuit is fairly good and inductive load can be handled fairly well. Reactive loads will smooth the output resulting in good wave shape. Several motor applications have been made using similar approaches. In one of these, a synchronous machine is started by frequency commutation at low speed or standstill. As the speed increases the counter *emf* of the machine will allow phase commutation.

Several abnormal commutation conditions have produced some interesting circuit approaches including some degree of correction for fault conditions, changes in deionization time, failure to fire, arc-backs, etc. As an example, if loss of grid control occurs in one of the devices, it is possible to limit the disturbance since

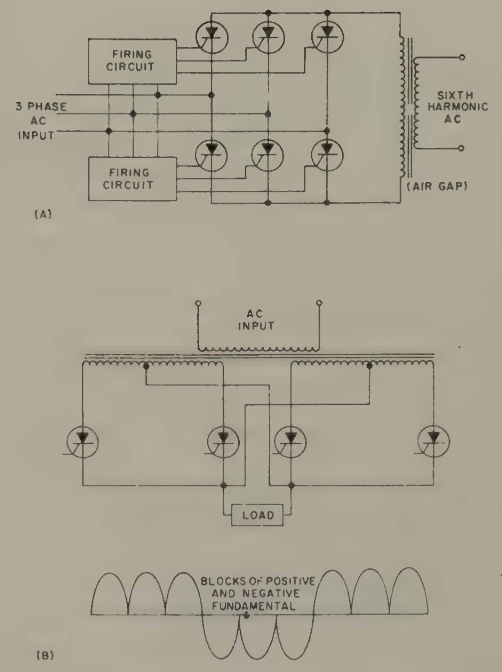

Fig. 9—(A) Frequency multiplier circuit. (B) Circuit using frequency commutation mode of operation.

each device is a rectifier as well as an inverter and the rectifier function attempts to commutate the fault current out of the device where the fault occurred. The circuit will continue with reduced power whereas the simple inverter becomes inoperative if a single device fails to function. Faults which clear themselves are characteristic of circuits using several rectifiers and inverter circuits in series. Several series capacitor commutated circuits have been developed for high frequency which can allow relatively large portions of an output cycle for deionization. This is obtained with poor utilization of equipment and in some cases with some loss in efficiency.

Transistor Techniques

Since in many applications, transistors and tubes are analogous, it follows that many of the conventional linear amplifier circuits may be utilized, such as the Colpitts oscillator as an example. These approaches usually are not very efficient, but may produce sinusoidal outputs.

There are a number of modes of operation which have been attempted paralleling to some extent vacuum tube techniques. A good example of this is Class A, AB or B linear operation, which utilizes push-pull power transistors in conjunction with linear feedback to compensate for voltage changes and harmonics. The efficiency of Class A operation is theoretically 50%, while for B, it is 78% and for switching Class D, it approaches 100%. Power conversion efficiency of motor generator sets is in the order of 80%. The amount of power obtainable from the transistor is also a function of the mode of operation. Pulse width modulation is a technique wherein square waves are

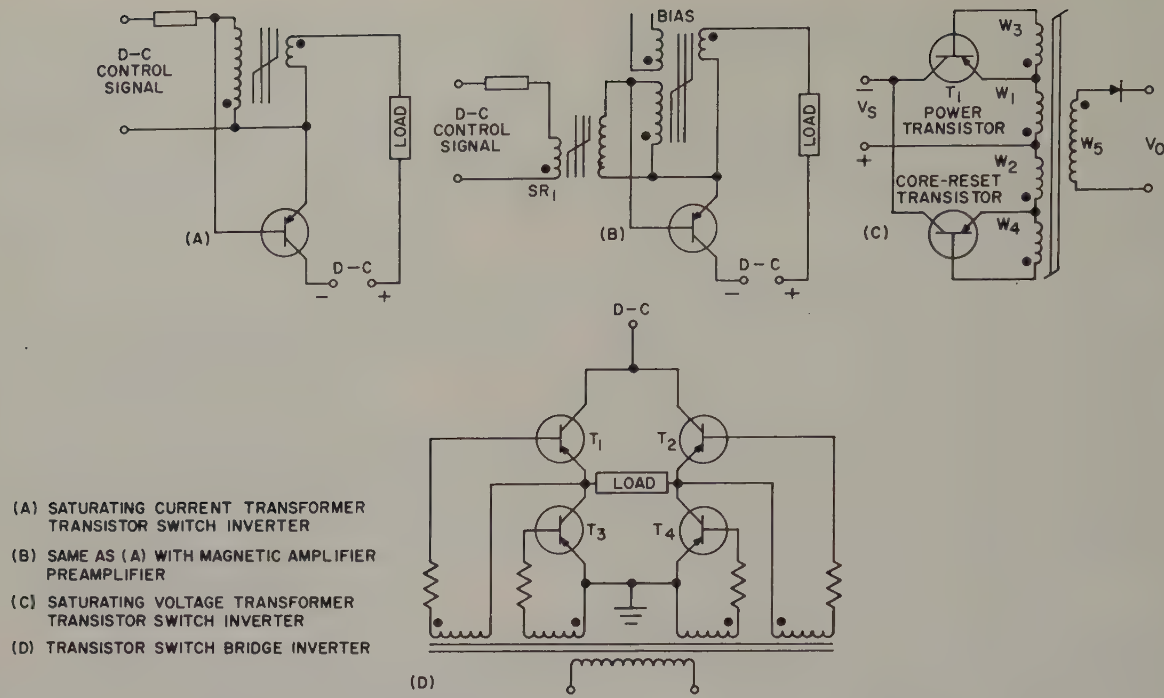

Fig. 10—(A) Saturating current transformer transistor switch inverter. (B) Same as (A) with magnetic amplifier preamplifier. (C) Saturating voltage transformer transistor switch inverter. (D) Transistor switch bridge inverter.

produced at frequencies higher than the desired output, thereby reducing filter requirements.

The switching or Class D mode of operation has received much attention. The transistors are operated as switches with resulting high efficiency. In this mode, the power handling capabilities are increased from 4 to 10 times over the proportional mode of operation. These units utilize the switching characteristics of the transistor by either allowing the transistor to be in the open condition characterized by very low leakage current, or in the completely saturated condition, characterized by very low forward resistance as shown in *Fig. 3*. There is, of course, a finite amount of power dissipated in the transistor during the interval when it is traversing the proportional region, as well as at the end points. This means that the frequency of the inverter will affect the efficiency of operation and determine the point at which de-rating will begin to be necessary to result in safe operation. Typically, the larger the power transistor becomes, the lower will be the usable frequency. At present, power transistors are limited to a lower frequency than the multijunction switching devices, such as the silicon controlled rectifier.

The circuits shown in *Figs. 10A* and *10B* are examples of single transistor inverters incorporating a saturable magnetic component[10]. Properly designed circuits operate at efficiencies comparable to more complex transistor approaches. The operation is such that the ratio of conducting time to off time may be varied in response to a controlling signal or fixed at any value by initial design. In this circuit the saturable current transformer carries full load current but not necessarily full load power. In some other circuit approaches wherein a saturating voltage transformer is used, it must be designed to carry full load power unless a preamplifier stage is used.

The time the transistor is turned on remains constant as long as the saturable current transformer core maintains the full excursion from positive to negative saturation. When the transistor is conducting, the saturable transformer operates as a normal current transformer wherein the power is supplied by the primary current and the secondary voltage is set by the secondary current and resistance. The transistor conduction time is determined by the secondary turns and the flux excursion. For a fixed supply, load, and transformer, the on time remains constant. The average load current which is a measure of the conduction period to off periods is a function of the *d-c* control signal. This control signal may be varied in response to an impedance change, voltage change or by the addition of a magnetic amplifier. Notice that in *Fig. 10B,* the gate voltage is derived directly from the pulsing present in the saturating transformer. Since the preamplifier is operated in the high impedance mode, the response is essentially half cycle.

The circuit of *Fig. 10C* uses two transistors in the switching mode and a saturating output transformer.[1] This particular configuration is one of many which have been developed in the past five years. The output of transistor saturating core inverters is basically square wave which is ideal for power supply use. If the frequency is relatively high, the unfiltered output ripple content can be as low as 2%. The output regulation will, of course, depend on the design. Typical

figures for an unregulated inverter are 6 to 12% while 0.1% accuracy can be achieved with properly designed regulating circuits. There is no restriction on the output voltage obtainable since this is merely a function of the turns ratio. The input voltage can be any value consistent with the voltage rating of the transistor and the circuit. The forward drop of the transistor, plus other circuit voltage drops will set the minimum input level.

Theoretically for a balanced circuit, starting is impossible since both transistors will pass identical currents and there will be no net magnetomotive force in a given direction on the core. However, since the probability of having identical parameters is slight, the device begins to oscillate on these irregularities. The flux built up in the core will be in the direction of the dissymmetry in the circuit. Thus, voltages are induced in the base windings such that the impedance of one is greatly reduced, while the other is increased being reverse biased. During the time the flux is traversing the side of the loop, load is being transformed. The voltage is ideally constant for constant input. When the core saturates, several effects take place simultaneously. Basically the induced base voltages collapse, thus leaving the transistor in a state of high impedance. Hence, the current in the transformer decreases causing a reversal of flux and necessarily opposite polarity of induced voltage. Therefore, the transistors are switched and the core drives towards negative saturation. Notice that the necessary "commutation" has taken place, being inherent in the circuit and not dependent on external circuit components. In a sense the commutation is volt-second sensitive, since it depends on core saturation. The voltage of interest is that which is flux producing and, therefore, is subject to *IR* drops and regulation. Commutation still results for load changes, transient disturbances, etc., but the frequency of oscillation will be changed as a result of reflected load changes.

In an improperly designed or uncompensated circuit approach, difficulty may be encountered during starting, even with a resistance load. This is particularly true in the case of square loop core materials where high residual flux levels can result after removal of power. Silicon iron with lower ratios of residual to maximum partly offset this problem. A number of designs have emerged which insure surety of starting under all conditions.

The basic circuit is not necessarily symmetrical since it may be desirable to have non-symmetrical half cycles which may readily be achieved with differences in turns. Likewise, both transistors need not be the same since one can serve the function of delivering power while a smaller unit may solely supply the reset requirements of the core. Under such conditions the reset time is a design parameter as well. In this circuit the minimum reverse voltage rating approaches twice the supply, while the exact ratio depends on turns ratio and half-cycle ratios. Likewise, additional control features can be incorporated by proper circuit design, such as regulation. In a sense, such circuits constitute the most general and all inclusive approach. The termination of each half cycle is determined by the saturation of the transformer, while the point in the half cycle at which output occurs depends on the driving signal supplied externally. Common emitter, common collector, and common base connections all have certain areas of application. Also individual or multichannel control of each transistor is possible.

The bridge circuit of *Fig. 10D* offers better utilization of the transistors since the maximum transistor peak inverse voltage is the supply voltage. In addition, the transformer is utilized to better advantage in this circuit and transistor failure resulting from transient voltage spikes associated with saturating transformer approaches are eliminated. Modifications of this circuit include transformer simplification through use of *n-p-n* and *p-n-p* transistors and self excitation.

Conclusions

A number of inverter concepts have been presented. The choice will depend on the application requirement, such as efficiency, size, weight, load requirements, etc. In general, the higher power applications where good efficiency is desired will favor the use of the solid state thyratron approaches whereas for lower power units (up to a few *KW*) and certain transient or infrequent methods of operation, the transistor approaches will be quite useful. In the latter case where the circuit is opened, energy loss may take place with the magnitude dependent upon the *kva* of the load. In the case of *d-c* to *d-c* conversion, this problem is minimized whereas for motor loads as an example, it may be more severe.

While it has not been specifically mentioned, the conduction angle of the current through the switching device is important. Circuit selection on the basis of optimum device utilization (both from a current and voltage standpoint) is important.

A number of references are included as a matter of interest. It should be pointed out that no attempt has been made to make this listing complete. The list of solid state inverter related patents is very indicative of the tremendous activity in this field and will be of considerable interest. All the patents involve transistor type switches. There are hundreds of patents both issued and expired concerning thyratron type circuits. These will be helpful in providing a base for further work. The degree of success which is likely to be achieved in devising new power inverter units using thyratron like solid state devices remains to be seen in view of the prior art.

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Applications Engineering Digests

APPLICATIONS ENGINEERING DIGEST NO. 33

How to Simplify Power Supplies, Referencing, and Instrumentation with Zener Diodes; International Rectifier Corp., El Segundo, California. (Oliver Allen)

Silicon Zener diodes have become such tremendously useful design tools in so short a time that few design engineers are acquainted with the countless possible applications of these new components.

By temperature controlling the Zener diode, it may be used as a precision reference element, or by temperature compensation and selection of temperature coefficients, stable reference voltages can be produced over wide temperature ranges.

They can also be used as clippers with an alternating current supply to produce square waves, or for voltage limiting, both *a-c* and *d-c,* as well as for wave shaping in voltage dividing circuits; e.g.-rms, log conversions, square law conversions, etc.

Zeners are capable of producing controlled bias voltages, such as needed in thyratron cathode biasing, and for holding a fixed bias in high fidelity audio equipment.

Coupling and de-coupling in *d-c* amplifiers, both vacuum tube and transistor, may be accomplished with Zener diodes.

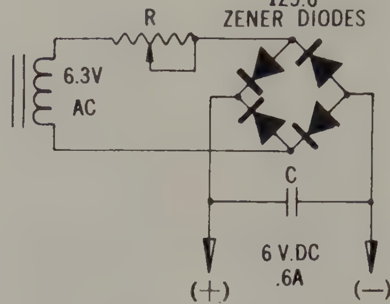

Fig. 33.1—Voltage controlled supply.

Voltage Limiting in DC Power Supply

Simultaneous voltage regulation and *d-c* rectification is achieved in the power supply circuit shown in *Fig. 33.1.* Here, Zener diodes provide voltage limiting or low order regulation in a *d-c* power supply. The Zener diodes are selected to act as clippers in connection with *R,* thus limiting the voltage to which capacitor *C* is charged. This provides control of a larger amount of power than is ordinarily handled by Zener diodes of this rating. At the same time, the diodes act as rectifiers in this circuit. This arrangement may be applied to a wide range of power supply requirements where extreme regulation is not a design necessity.

Low Ripple DC Regulated Filament Supply

Zener diodes in combination with a power transistor will provide the low ripple *d-c* regulated filament supply shown in *Fig. 33.2.* This extremely stable supply offers good regulation to both line and load variations for a wide variety of audio and instrumentation applications. This combination of components provides regulation and filtering that is ordinarily difficult to accomplish at low voltages and high currents.

Expanded Scale Instrumentation

The circuit in *Fig. 33.3* shows the use of Zener diodes in expanded scale instrumentation, where a compressed lower scale and expanded upper scale is achieved, both of which may be calibrated. The relative areas and sensitivities of the scale will be determined by the componet values selected. This circuit offers greater accuracy over the upper portion of the instrument scale, while still allowing rough measurements to be made in the lower scale range.

[Circle 198 on Reader Service Card]

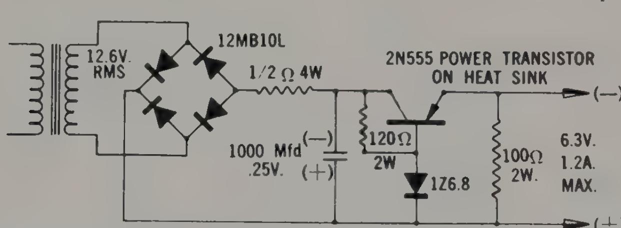

Fig. 33.2—Low ripple d-c regulated filament supply.

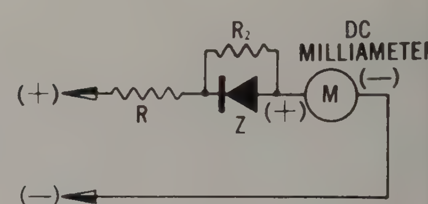

Fig. 33.3—Upper scale expansion.

APPLICATIONS ENGINEERING DIGEST NO. 34

Multivibrator Circuits; Shockley Transistor Corp., Palo Alto, California.

Circuit Operation

Astable Multivibrator Circuit (Fig. 34.1)

In the astable, or free-running multivibrator circuit, the two legs of the circuit are arranged so that power is automatically transferred from one leg to the other without the need of an external trigger. This transfer is accomplished by setting the supply voltage at a level greater than the switching voltage of the four-layer diodes *4D1* and *4D2.*

Assume that diode *4D1* has just turned on, point "A" will be at approximately ground potential as long as the current passed by resistance *R1* is greater than the holding current of *4D1.* As the commutating capacitor *C1* charges through resistor *R2,* the voltage at point "B" increases until it reaches the switching voltage of diode *4D2.* When this occurs, *4D2* switches on, and point "B" is brought suddenly down to ground potential. At the instant of switching, there is a negative to positive potential across capacitor *C* between points "A" and "B". Therefore,

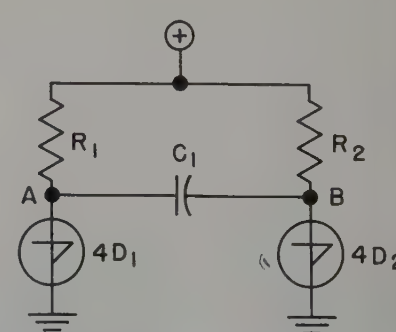

Fig. 34.1—Astable (free-running) multivibrator circuit.

as point "B" is pulled down to ground potential, point "A" is driven to a negative potential before *C1* has a chance to discharge. This reverse bias turns diode *4D1* off, and *4D2* now carries the load current through *R2*. Capacitor *C1* then charges in the opposite direction through resistor *R1* until point "A" reaches the switching voltage of diode *4D1*. As this occurs, diode *4D1* switches on, the voltage across *C1* turns diode *4D2* off, and load current once more flows through resistor *R1*.

The operating frequency is determined by the time constants *R1-C1* and *R2-C1*, and by the ratio of the supply voltage to the switching voltage *(Vs)* of the four-layer diodes *4D1* and *4D2*. The circuit can be made symmetrical, but can also be made to stay longer on one side than the other by making the time constants *R1-C1* and *R2-C1* unequal, or by using four-layer diodes whose switching voltages are unequal.

Monostable Multivibrator Circuit (Fig. 34.2)

In the monostable or one-shot configuration, the circuit is arranged so that one leg is normally on, the other normally off. This is accomplished by choosing *4D1* to have a switching voltage less than the supply voltage, and *4D2* to have a switching voltage greater than the supply voltage.

A negative-going trigger pulse injected via capacitor *C2* switches *4D2* on, which in turn switches *4D1* off through the coupling action of *C1*. If *R2* passes current to *4D2* greater than its holding current, *4D2* will remain on until capacitor *C1* has been charged through resistor *R1* up to the switching potential of *4D1*, at which time the circuit reverts to its initial stable condition with *4D1* on. In this operating mode, the time constant *R1-C1*, and the ratio between supply and the switching voltage of *4D1* determine the duration of the period during which leg "B" will stay on. The trigger input can be randomly spaced, but the maximum operating frequency will be limited by the "on" period for leg "B".

A second operating mode may be employed, in which *R2* is made large enough that it does not pass holding current for diode *4D2*. A trigger pulse

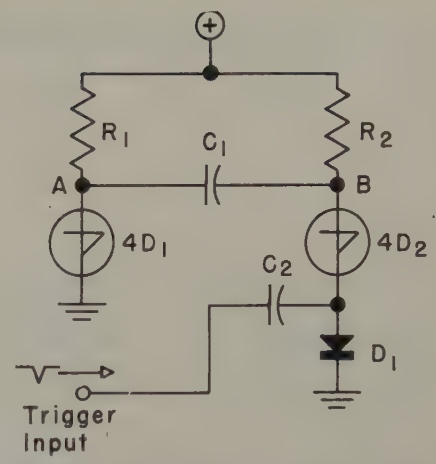

Fig. 34.2—Monostable (one-shot) multivibrator circuit.

inserted via *C2* then produces a pulse in circuit "B" of very short duration, following which the circuit reverts to its original condition with leg "A" conducting. Care must be taken to select the right values for *R1, C1,* and the holding currents of *4D1* and *4D2*.

APPLICATIONS ENGINEERING DIGEST NO. 35

Switching Circuits — Recovery Time Measurements; Hoffman Electronics Corp., Evanston, Ill. (W. MacDonald)

A semiconductor diode, when switched from forward current conduction to a reverse bias condition, will, for a short time, allow passage of an appreciable amount of current in the reverse direction. This effect is caused by the phenomenon of "charge storage," or, more specifically, "minority carrier storage."

The initial low reverse impedance that occurs during reverse switching is of serious concern to the design engineer, and a number of test circuits have been proposed to aid the designer in predicting the probable performance of a particular diode in a given switching circuit. A number of these circuits are illustrated on these pages.

Figure 35.1 is a simplified schematic of one of the earliest standard test circuits, the JAN-256. In this circuit, forward bias is supplied by the $+150v$ plate supply, the diode is switched off by the external square-wave generator, and the time required for the initial diode reverse current to decay to the specified value is measured by observing the voltage drop across R_L. Since it is usually necessary to measure the time required for the diode to reach a high reverse impedance (small reverse current), it is necessary that R_L be relatively large. In order to allow reasonable supply voltages, and to prevent overdriving the oscilloscope input stages during the forward current pulse, a "reference diode" is placed across R_L to clamp the drop across R_L to a low value.

Since the JAN-256 circuit uses a semiconductor clamp, there is some question as to the accuracy of this circuit. An alternative circuit is that described in EIA SP590 as Method 1

(Continued on page 72)

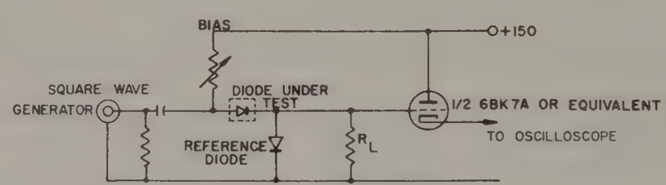

Fig. 35.1—JAN-256 test circuit.

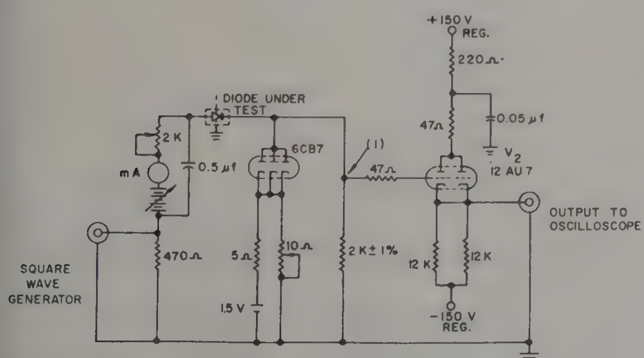

Fig. 35.2—E.I.A. proposed standard circuit.

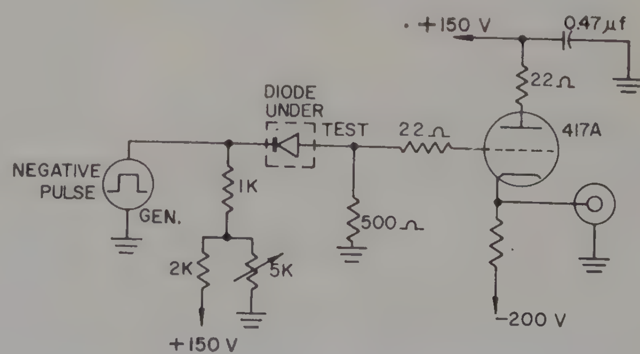

Fig. 35.3—Modified Bureau of Standards circuit.

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An R-F Power Transistor	Bell Labs Record October 1959	Description of a transistor that operates at 10 *mc* with a power output of 5 watts.	J. E. Iwerson J. T. Nelson
The Variable-Capacitance Parametric Amplifier	Bell Labs Record October 1959	Discussion of negative-resistance parametric amplifier, variable-capacitance effect in semiconductor diodes, and the up-conversion amplifier.	E. D. Reed
A Survey of Temperature Measuring Techniques	Brit Comm & Elecncs October 1959	Description of measuring techniques; chart provided to help select the best type of instrument for a given application.	W. A. Seatherton
Reference Sources for Industrial Potentiometric Instruments	Brit Comm & Elecncs October 1959	The accuracy of a potentiometric depends on its reference voltage. Zener diodes provide a useful alternative to the standard cell.	G. B. Marson
Low-Noise, Solid State Microwave Amplifiers	Electrical Mfg October 1959	Basic principles of paramagnetic maser amplifiers and paramagnetic mavar amplifiers, with brief introduction to the tunnel-diode amplifier.	R. D. Haun Jr. T. A. Osial
Logic-Circuit Modules for Industrial Control Systems	Electrical Mfg October 1959	Basic circuit modules, such as flip-flops, are combined into building blocks, which in turn are combined to make up a system.	W. Floyd
Achieving Stable High-Frequency Design With The Mesa Transistor	Electronic Design October 14 1959	Design procedure, unilateralization by mismatching, permits direct determination of stability and performance from mfr's data sheets.	D. G. Paterson
Diode in Feedback Loop Makes Stable Transistor Bias Circuit	Electronic Design October 14 1959	By adding a constant-potential device to transistor amplifier bias networks, excellent stability is obtained without sacrifice in gain.	C. F. Montgomery
The Design of Transistor Push Pull D. C. Convertors	Electronic Engg (Br) October 1959	Design formulae are derived in terms of operating parameters of a system using a transistor square wave oscillator controlled by a saturating transformer.	W. L. Stephenson L. P. Morgan T. H. Brown
Charts for Deriving Transistor r-Parameters from h-Parameters	Electronic Engg (Br) October 1959	Charts are described whereby the inference of the values of the r-parameters of a transistor from its measured grounded-base h-parameters is simplified.	G. W. E. Stark
An Electronic Tachometer for Automobiles	Electronic Engg (Br) October 1959	An electrical signal proportional to engine speed is utilized in a diode pump frequency-measuring circuit calibrated directly in terms of engine speed.	M. J. Wright
A Simple Transistor Tester	Electronic Engg (Br) October 1959	A simple and inexpensive instrument is described for the measurement of the more useful parameters, I_{co}, β, h_{11}', and f_a.	G. G. Yates
A Transistor Scaling Circuit with a Short Resolving Time	Electronic Engg (Br) October 1959	Discussion of scale-of-two circuit coupled to another by a gate circuit.	B. Collinge
Approximate Waveform Solutions for Diodes in Pulse Circuits	Electronic Engg (Br) October 1959	Waveform solutions are obtained for a group of simple circuits to which rectangular or triangular waveforms are applied.	D. C. Dillistone
A Transistor Blocking Oscillator Frequency Divider	Electronic Engg (Br) October 1959	The frequency divider includes a "Staircase" waveform generator designed to produce a multiple step waveform in which all the voltage increments are equal in amplitude.	F. Butler
Diode Phase Sensitive Detectors with Load	Electronic Engg (Br) October 1959	A theoretical investigation of the operation of the simple diode push-pull phase-sensitive detector with load is carried out.	R. Chidambaram S. Krishnan
An Investigation Into Some Aspects of Diode Quantizing Circuits	Electronic Engg (Br) October 1959	Three circuits are compared both theoretically and by measurement, and the results presented. A possible application of these circuits is then described.	H. V. Bell W. Alexander
Leakage Current Tester for Transistors and Diodes	Elecnc Equip Engg October 1959	Complete design and circuitry for measuring reverse leakage current from collector to base, and other leakage parameters.	C. D. Todd
Complementary Logic Circuits	Elecnc Equip Engg October 1959	Two types of switching circuits using complementary *n-p-n* and *p-n-p* alloy transistors are analyzed.	L. Delhom
Semiconductor Reference Assemblies	Elecnc Equip Engg October 1959	Silicon reference element and temperature compensating and regulating units comprise a reference pack.	H. Nash G. Porter
Designing Solid State Binary Memory Circuits	Elecnc Equip Engg October 1959	An approach to binary memory circuits utilizing a *p-n-p-n* bistable switch which permits simplified circuits.	J. B. Hangstefer L. H. Dixon Jr.
Transistor Preamplifier Design	Elecnc Industries October 1959	Design requires consideration of the normal recording level, pickup characteristics, and output level requirements.	H. J. Paz
Thermistors . . . 10 to 600°K	Elecnc Industries October 1959	Types and materials presently available with special emphasis on a wide temperature scope.	H. B. Sachse
Flip-Flop Circuit using Saturated Transistors (Part 2)	Elecnc Industries October 1959	The method presented here separates the design into a steady state solution and a transient solution.	J. E. Hull
Transistor "L" Parameters	Elecnc Rad Engr (Br) October 1959	An experimental investigation was made in order to develop a test-set suitable for measurement of the complex parameters.	R. Hutchins J. D. Martin
Transistors in Magnetic Fields	Elecnc Rad Engr (Br) October 1959	Characteristics of *p-n-p* alloy junction transistor with common-emitter configurations have been studied when subjected to a magnetic field.	P. C. Trivedi G. P. Srivastava
Compact Memories Have Flexible Capacities	Electronics October 2, 1959	Modular design using transistors of the Feramic core coincident-current memory is described.	D. Haagens
Equations for Designing Transistor Power Supplies	Electronics October 2, 1959	Clear development of design; includes operation, core selection transformer design, transistor selection, and performance.	T. Hamm Jr.

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Power Supply Design using Silicon Diodes	Electronics October 2, 1959	Applications of silicon diodes in a 200 KW power supply: discussion includes peak inverse voltage considerations and diode connections for proper design.	H. A. Kampf
Constant Current Coupled Transistor Power Supply	Electronics October 9, 1959	By driving a constant current through a fixed resistance, the total error voltage of a power supply can be fed into an error-correcting amplifier.	E. Gordy P. Hasenpusch
Inverse Feedback Stabilizes Dry Cell Current Sources	Electronics October 1959	Errors in test instruments that draw heavy currents from dry cells are reduced with transistor circuit that maintains constant current.	G. E. Fasching
Operational and Storage Life of Silicon Rectifiers	Electronics October 16, 1959	Results of life tests measuring forward voltage drop and reverse leakage current of four rectifier types at 25° C and 150° C.	C. L. Hanks
Multiplexing Techniques for Satellite Applications	Electronics October 30, 1959	Description of transistorized 10-channel multiplex system that accepts conventional as well as random pulse inputs.	O. B. King
Esaki Tunneling	IBM Jl R&D October 1959	Tunneling is discussed in terms of customary quantum transition theory for the matrix elements of the hamiltonian between the states representing reflection of an electron (in either band) from the junction.	P. J. Price J. M. Radcliffe
A 3000-Mc Lumped-Parameter Oscillator Using an Esaki Negative Resistance Diode	IBM Jl R&D October 1959	Communication describes a design approach based on lumped-parameter principle which is free from parasitic oscillations arising in low-impedance d-c source circuits.	R. F. Rutz
Cross Modulation and Nonlinear Distortion in RF Transistor Amplifiers	IRE Trans Elecnc Dev October 1959	Measured curves of cross modulation vs collector bias current show a sharp minimum; this is accounted for by previously neglected terms.	M. Akgun M. J. O. Strutt
Diffused Silicon Nonlinear Capacitors	IRE Trans Elecnc Dev October 1959	Design and fabrication of diodes which may be used as low-noise microwave amplifiers.	A. E. Bakanowski N. G. Cranna A. Uhlir, Jr.
Space Charge Layer Width in Diffused Junctions	IRE Trans Elecnc Dev October 1959	Calculation of space-charge layer width in a planar junction made by diffusing an n- or p-type impurity into a uniformly doped crystal of opposite conductivity types.	R. M. Scarlett
The Cylindrical Field Effect Transistor	IRE Trans Elecnc Dev October 1959	The characteristics are derived analytically on the basis of Shockley's theory of the planar field-effect transistor.	H. A. R. Wegener
Cleaning of Silicon Surfaces by Heating in High Vacuum	Jl Applied Phys October 1959	Results prove that an atomically clean surface can be produced by heating to 1550°K or above for several minutes in a high vacuum.	F. G. Allen J. Eisinger H. D. Hagstrum J. T. Law
The Use of Organo-Substituted Hydrolyzable Silanes on Silicon Devices	Jl Electrochem Soc October 1959	The formation of silicone polymers directly from the monomers, on the surface of silicon diodes, has resulted in devices with low reverse currents.	B. Schwartz
The Temperature Dependence of the Low-Level Lifetime and Conductivity Mobility of Carriers in Silicon	Jl Elecncs & Cont (Br) August 1959	Consistency is found with the theory based on a low level of injection, a low density of recombination centers, and a single energy level for the recombination centers.	D. M. Evans
A Modification of the Theory of the Variation of Junction Transistor Current Gain with Operating Point and Frequency	Jl Elecncs & Cont (Br) August 1959	Experimental results show that both electrical and metallurgical base widths are smaller than are normally supposed.	A. W. Matz
The Thermoelectric Figure of Merit and its Relation to Thermoelectric Generators	Jl Elecncs & Cont (Br) July 1959	The results are discussed in connection with bismuth telluride and other sulphides, selenides and tellurides of the heavy metals.	R. P. Chasmar R. Stratton
The Figure of Merit of a Thermoelectric Generator	Jl Elecncs & Cont (Br) July 1959	Optimum conditions are deduced for a thermo-electric generator or refrigerator with n- and p-type semiconducting branches whichc have different physical parameters.	R. Stratton
Approximation Errors in Diode Function-Generators	Jl Elecncs & Cont (Br) July 1959	Electronic errors resulting from fitting a piecewise linear function to a smooth curve are discussed.	R. N. Ream
The Seebeck Coefficient of Bismuth Single Crystals.	Jl Phys & Chem Solids Nos 3/4 Vol 11 1959	The Seebeck coefficient, S, of single crystals of bismuth has been measured between room temperature and about 250° C.	B. S. Chandrasekhar
Measurement of the Hall Effect and Conductivity of Super-Pure Silicon	Jl Phys & Chem Solids Nos 3/4 Vol 11 1959	With the floating-zone technique super-pure, uncompensated p-type silicon with a resistivity above 100,000 ohm/cm has been obtained and measured.	A. Hoffman K. Reuschel H. Rupprecht
Adsorption on Clean Germanium Surfaces	Jl Phys & Chem Solids Nos 3/4 Vol 11 1959	The adsorption of various gases on clean germanium surfaces has been investigated.	M. Green K. H. Maxwell
Solid Solubilities of Aluminum and Gallium in Germanium	Jl Phys & Chem Solids Nos 3/4 Vol 11 1959	Crystal-pulling and thermal-gradient techniques have been used to determine solubilities in the ranges from 500° and 300° C respectively to the melting point of germanium.	F. A. Trumbore E. M. Porbansky A. A. Tartaglia
Photoelectric Emission and Work Fractions of InSb, GaAs, Bi_2Te_3 and Ge.	Jl Phys & Chem Solids Nos 3/4 Vol 11 1959	Measurements have been made of the energy distributions of photoelectrons emitted by various semiconductor surfaces.	D. Haneman
The Field Dependence of the Mobility of Electrons in n-Germanium	Jl Phys & Chem Solids October 1959	The mobility of electrons in n-Ge at an arbitrary field strength is calculated by assuming the distribution function in a given mathematical form.	H. Sato
On Galvanomagnetic Effects in p-Type Crystals of PbTe	Jl Phys Soc Japan October 1959	This paper describes measurements of magnetoresistance and of the planar Hall Effect of p-type PbTe crystals.	K. Shogenji
Circuit for the Protection of a Stabilized Transistor Power Supply	Mullard Tech Comm August 1959	The overload protection circuit described can switch off the supply in less than 50 microseconds.	H. Kemhadjian A. F. Newell

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Dendritic Growth of Germanium Crystals	Physical Review October 1, 1959	Controlled dentritic growth of germanium from the melt yields long thin strips whose principle surfaces are optically flat crystallographic plates except for the occasional presence of small steps.	A. I. Bennett R. L. Longini
Depletion-Layer Photoeffects in Semiconductors	Physical Review October 1, 1959	A theory of photoconduction through the reverse-biased p-n junction in semiconductors is developed.	W. W. Gartner
High-Field Effect in Boron-Doped Silicon	Physical Review October 15, 1959	Simple experiments which indicate that at low temperature and high applied electric fields, several mechanisms may increase majority carrier current.	R. D. Larrabee
Energy Levels in Neutron-Irradiated n-Type Silicon	Physical Review October 15, 1959	Experiments provide evidence in favor of two, deep-lying states in the upper part of the energy gap below the conduction band edge.	G. Rupprecht C. A. Klein
New Parallel Photoelectromagnetic Effect	Physical Review October 15, 1959	The short-circuit current is proportional to the difference in surface recombination velocities of a pair of parallel surfaces.	A. Amith
Generation of Harmonics and Sub-Harmonics at Microwave Frequencies with P-N Junction Diodes	Proceedings IRE October 1959	The performances of a non-linear resistance and a non-linear capacitance in a broadband harmonic generator circuit are analyzed. Experimental results with a capacitance diode are given.	D. Leenov A. Uhlir Jr.
Recombination Relaxation Effects in Germanium Surfaces	Proc Phys Soc (Br) September 1959	The conductance of a thin single crystal slab of germanium has been modulated by a small electric field capacitively applied to the larger face.	D. H. Lindley P. C. Banbury
Hall Coefficient and Magneto-resistance in Semiconducting Diamond	Proc Phys Soc (Br) September 1959	Measurements on two type II-b p-tvpe specimens were made as a function of the magnetic field between 0° and 100° C.	R. T. Bate R. K. Willardson
The Measurement of Optical Radiation	Res Appd In Ind (Br) Oct/Nov 1959	Methods used in a standardizing lab for making absolute measurements of radiation in the ultra-violet, visible, and infra-red.	E. J. Gillham
The Growth of Oxide Single Crystals Containing Transition Metal Ions	Res Appd In Ind (Br) Oct/Nov 1959	Methods are described which overcome some of the difficulties: the flame fusion process, the Bridgman Stockbarger, and the lead oxide solution methods.	F. W. Harrison
Solid State Devices	Res Appd In Ind (Br) Oct/Nov 1959	Survey of some devices that have been made possible, in particular those using indium antimonide.	I. J. Richmond
Principle of a Semiconductor Manometer in the Pressure Range of 1 to 10^{-6} mm Hg	Rev Sc Instruments October 1959	Experiments investigating the use of semiconductors for low-pressure measurements proved that thermistors give the best results.	M. Varicak B. Saftic
Small, Lightweight Ionization Gauge Control Circuit	Rev Sc Instruments October 1959	A lightweight compact thermionic ionization gauge control is described, with emission regulation achieved by using a transistorized feedback amplifier.	H. B. Benton
Improved Automatic Four-Point Resistivity Probe	Rev Sc Instruments October 1959	A continuously recording automatic four-point resistivity probe is described.	D. Dew-Hughes A. H. Jones G. E. Brock
Frequency Multiplication and Division By Semiconductor Diodes	Semiconductor Prods October 1959	Examples of harmonic generation yields obtained with nonlinear capacitance diodes are given to illustrate the superiority of these devices.	D. Leenov A. Uhler, Jr.
Large Signal Characteristics of The Silicon Unjunction Transistor	Semiconductor Prods October 1959	An equivalent circuit is used to describe the important electrical characteristics, and to predict their variation with bias point and temperature.	T. P. Sylvan
A Production Method for Measurement of Rise, Fall, and Storage Time	Semiconductor Prods October 1959	Measurements are obtained rapidly with relatively simple and inexpensive test equipment.	D. G. Paterson
Flow Graph Analysis of Transistor Feedback Networks	Semiconductor Prods October 1959	The flow graph technique is used for analyzing the four basic transistor feedback circuits.	P. Kaufmann J. J. Klein
Core Memory Systems	Sylvania Technologist October 1959	Description of general problem, followed by a presentation of new techniques that overcome some of the difficulties.	A. Ashley S. Bradspies E. Cohler
Analysis of Transistor-Resistor-Logic Circuit Propogation Delay	Sylvania Technologist October 1959	Description of transistor and TRL circuit studies.	W. J. Dunnet E. P. Auger A. C. Scott
Basic Theory of the Tunnel Diode	Sylvania Technologist October 1959	A negative-resistance region occurs in the forward characteristic. Basic principles that give rise to this negative resistance are briefly explained.	E. M. Conwell
Industrial Preparedness Study on High Voltage Silicon Rectifiers	US Govt Res Repts August 14 1959 LC $12.30 PB136735	A new alloying technique was devised giving improved yields and electrical properties. An evaluation of silicon suitable for high voltages has been initiated.	R. W. Hull
Solid State Chemistry	US Govt Res Repts August 14 1959 OTS $1.00 PB151440	About 75 research papers and corresponding publications on investigations into the nature of the solid state are reviewed; includes semiconductors generated by partial oxidation or reduction.	W. A. Weyl E. C. Marbor
Engineering Services on Transistors	US Govt Res Repts August 14 1959 LC $13.80 PB140251	Topics discussed are: transistor reliability, new and improved-type transistors, transistor test methods, and transistor circuit components.	M. M. Atalla M. Lindner et al
Contributions to Transistor-RC Network Synthesis	US Govt Res Repts August 14 1959 LC $18.30 PB140237	Author reports that the use of the negative impedance converter and of controlled sources stereotypes essentially all existing network realizations.	B. R. Myers
Transistor Operational Amplifier, Effect of Input Impedance on Accuracy	US Govt Res Repts August 14 1959 LC $4.80 PB139954	The utilization of transistors in operational amplifiers necessitates the consideration of unique amplifier properties.	J. Engel
The Thermergistor: A Low Energy Pulse Measuring Device	US Govt Res Repts August 14 1959 OTS $0.50 PB151686	This device is constructed by noninductively winding a short length of resistance wire about a resistor.	J. C. Chambers G. R. Bastedo

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHORS
Research in Physical Chemistry and Metallurgy of Semiconducting Materials	US Govt Res Repts August 14 1959 LC $4.80 PB136614	Studies of single-crystal germanium-silicon alloys prepared by horizontal growth methods, and by co-deposition from the vapor phase.	R. K. Reil W. E. Medcalf
Research in Physical Chemistry and Metallurgy of Semiconducting Materials	US Govt Res Repts August 14 1959 LC $4.80 PB136615	Preparation of single-crystal germanium alloys. Chemistry of trichlorosilane and silicon tetrabromide. Studies of tantalum silicide.	R. K. Reil W. E. Medcalf
Research in Physical Chemistry and Metallurgy of Semiconducting Materials	US Govt Res Repts August 14 1959 LC $4.80 PB136661	Studies of trichlorosilane with preparation of elementary silicon therefrom.	R. K. Reil W. E. Medcalf
Research in Physical Chemistry and Metallurgy of Semiconducting Materials	US Govt Res Repts August 14 1959 LC $4.80 PB136662	Purification of silicon and silicon halides.	R. K. Reil W. E. Medcalf
Research in Physical Chemistry and Metallurgy of Semiconducting Materials	US Govt Res Repts August 14 1959 LC $6.30 PB136663	Drose formation in silicon prepared from $SiHCl_3$. Tantalum and boron in silicon.	R. K. Reil W. E. Medcalf
Research in Physical Chemistry and Metallurgy of Semiconducting Materials	US Govt Res Repts August 14 1959 LC $6.30 PB136664	Studies of trichlorosilane, silicon tetrachloride, and elemental silicon from $SiCl_4$.	R. K. Reil W. E. Medcalf
Research in Physical Chemistry and Metallurgy of Semiconducting Materials	US Govt Res Repts August 14 1959 PB $6.30 PB136665	Studies of trichlorosilane. Effect of traces of hydrocarbons and carbon monoxide in hydrogen, method of removal.	R. K. Reil K. E. Bean W. E. Metcalf
Research in Physical Chemistry and Metallurgy of Semiconducting Materials	US Govt Res Repts August 14 1959 LC $7.50 PB136666	Purification of $SiHCl_3$, by absorption techniques. Study of the purity of water and its effect on silicon. Floating zone studies.	K. E. Bean R. K. Reil W. E. Metcalf
Variable Capacitance Diodes	US Govt Res Repts August 14 1959 LC $7.80 PB140253	The design theory of the AFC and PM modulator type variable capacitance diode is presented in detail.	L. S. Chase H. D. Frazier
Semiconductor Comparator Circuit	US Govt Res Repts August 14 1959 LC $15.30 PB140683	Advantages are found in using semiconductor rather than thermionic diodes, and regenerative rather than non-regenerative circuits, in comparison performance.	G. L. Hoehn, Jr.
Audio-Frequency Noise Figures of P-N-P Alloy-Junction Germanium Transistors	US Govt Res Repts August 14 1959 LC $15.30 PB140319	This report presents the results of noise figure measurements; also a theoretical model of a transistor with noise is described and comparisons made thereof.	F. E. Stuart
A Survey on Silicon Carbide	US Govt Res Repts August 14 1959 LC $9.30 PB140413	A survey of the literature and developments in silicon carbide including crystallographic material, electrical, optical, and device aspects.	M. Minamoto
Investigation and Measurements of Properties of Single Crystal Silicon	US Govt Res Repts August 14 1959 LC $4.80 PB140634	Measurement techniques for evaluating quality include lifetime studies and galvanomagnetic measurements.	A. C. Beer
Investigation of Surface Properties of Silicon and other Semiconductors	US Govt Res Repts August 14 1959 LC $3.30 PB140638	Direction patterns from a (111) InSb surface are described. Measurements on recombination velocities at a germanium surface are reported.	H. E. Farnsworth D. Haneman J. B. Marsh
Growing of Cadmium Sulfide Crystals for Dosimeter Purposes	US Govt Res Repts August 14 1959 LC $13.80 PB138213	CdS single crystals can be obtained by a sublimation-condensation process in a helium atmosphere with crystal deposition on polished clear silica plates.	J. E. Powderly K. E. Bean
Effect of Heavy Doping on the Diffusion Impurities in Germanium	US Govt Res Repts August 14 1959 LC $9.38 PB140400	The diffusion coefficients of indium, antimony, arsenic, and tin were measured in arsenic-doped, intrinsic germanium and gallium doped Ge from 750° to 875°C.	M. W. Valenta
Internal Photoeffect and Exciton Diffusion in Cadmium and Zinc Sulfides	US Govt Res Repts August 14 1959 LC $7.80 PB136775	The spectral response of photoconductivity were measured for several distances between the area of illumination and the electrode region.	M. Balkanski R. D. Waldron
Transmission Line Formation for Semiconductors	US Govt Res Repts August 14 1959 LC $3.30 PB140596	An alternative derivation of the scattering coefficients Tj1 by a variational method is given in this quarterly report.	P. Parzen
Semiconductivity in Cadmium Telluride	US Govt Res Repts August 14 1959 LC $18.30 PB140390	Hall coefficient and resistivity measurements were made in single crystals of CdTe both "pure," with added impurities, and in hot-pressed polycrystalline specimens.	J. L. Stull
The Determination of Submicrogram Qualities of Boron in High Purity Silicon Metal	US Govt Res Repts August 14 1959 LC $6.30 PB136046	Because of large amounts of nitrogen, the proton irradiation was not successful. In the deuteron irradiations the boron presence in parts per billion was measureable.	
Preparation and Properties of Cadmium Sulfide Photoconductors	US Govt Res Repts August 14 1959 LC $4.80 PB138786	Investigations indicate that inherent limitations make these materials impractical at the present time for display devices; however there are other electro-optic device possibilities.	J. Graham F. Keller et al
Transistor Technology Evolution—II	West Elec Engr October 1959	Other technologies, semiconductor materials, surfaces, and encapsulations.	A. E. Anderson

PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from Oct. 15, 1957 to Dec. 3, 1957. In subsequent issues, patents issued from Dec. 3, 1957 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT REVIEW will appear periodically, the treatment given to each item being more detailed.

October 15, 1957
2,810,110 Semiconductor Modulation Circuits—H. J. Paz. Assignee: Radio Corporation of America. A modulator circuit which uses a pair of opposite conductivity type transistors to provide wide frequency response and stable, efficient circuit operation.

October 22, 1957
2,810,831 Cross Coupling for Astable Circuits—C. E. Jakielski. Assignee: Bell Telephone Laboratories. A transistor, emitter-coupled multivibrator with a capacitor connected between the base of one transistor and ground, and with a conventional capacitance cross-coupling circuit from the collector of the same transistor to the base of the other transistor.

2,810,843 Alternating Current Motor—C. E. Granquist. Assignee: Svenska Aktiebolaget Gasaccumulator (Sweden). An *a-c* motor having a stator winding forming the oscillator coils of a transistor converter for converting *d-c* to *a-c* in order to drive the motor.

2,810,870 Switching Transistor—L. P. Hunter, R. F. Rutz, G. L. Tucker. Assignee: International Business Machine Corporation. A switching transistor made by the gaseous diffusion technique wherein the minority carrier injection efficiency of the emitter junction is constant over the entire area of the junction.

2,810,871 Rectifier Assemblies—C. S. Weyandt. Assignee: None. A rectifier comprising a plurality of plates in stacked relationship, two spaced insulating posts supporting the assembled stack, and stack clamping means for retaining the stack under pressure.

2,810,872 Metallic Rectifier Mounting Structure—G. L. Nord, A. W. Mueller. Assignee: Schauer Manufacturing Corporation. A mounting structure for a stack of metallic rectifying disks and terminals which produces an effective and uniform clamping pressure for rectifiers so constructed.

2,810,873 Transistors—R. D. Knott. Assignee: The General Electric Company, Ltd. A transistor comprising a semiconductor body housed in an envelope the major portion of which is metallic, the base electrode of said transistor being comprised of a metallic member connected in intimate contact to the semiconductor body over a large area thereof and bearing against the internal surface of the metallic part of the envelope.

*Source: Official Gazette of the U. S. Patent Office and Specifications and Drawings of Patents Issued by the U. S. Patent Office.

October 29, 1957
2,811,474 Semiconductor Devices—L. D. Armstrong. Assignee: Radio Corporation of America. A semiconductor device comprising a body of germanium, an electrode fuzed thereto, and a *p-n* junction adjacent to said electrode, said electrode being comprised of an alloy of 20%-65% lead, 25%-70% bismuth, 10%-30% antimony.

2,811,590 Series-Energized Cascade Transistor Amplifier—J. A. Doremus, R. P. Crow, H. Korn. Assignee: Motorola, Inc. A multi-stage transistor repeater circuit in which the *d-c* feed to the stages is by a series circuit through all the stages so that the entire repeater circuit requires very small drain from a high voltage source.

2,811,643 Transistor Oscillator—E. Eberhard. Assignee: Motorola, Inc. A simple, compact oscillator unit that will start under all normal temperature and load conditions and which draws low current from the potential source thereof.

2,811,646 Transistor Oscillator Circuit—H. B. Yin. Assignee: Radio Corporation of America. An oscillation generator utilizing a tetrode transistor as the active element thereof wherein very high frequency signal operation is obtainable by utilizing the interelectrode capacitance of said transistor to provide the feedback necessary to sustained oscillations.

2,811,653 Semiconductor Devices—A. R. Moore. Assignee: Radio Corporation of America. In an *n-p-n* or a *p-n-p* transistor, a base region comprising two layers of material of the same conductivity type but of differing conductivity, the high conductivity layer being adjacent to the emitter and the low conductivity layer is between the base and the collector.

2,811,682 Silicon Power Rectifier—G. L. Pearson. Assignee: Bell Telephone Laboratories. A silicon power rectifier that is characterized by both low internal losses and a capacity for tolerating substantial temperature rises.

November 5, 1957
2,812,235 Method of Purifying Volatile Compounds of Germanium and Silicon—F. H. Winslow. Assignee: Bell Telephone Laboratories. A method consisting of the steps of contacting the material to be purified with chlorotriphenolmethane or fluorotriphenolmethane, maintaining contact until the germanium or silicon have formed a complex with the volatile impurities, and separating the compounds of the complex.

2,812,273 Method of Taking Titanium-Dioxide Rectifiers—T. S. Shilliday, C. S. Peet, A. E. Middleton. Assignee: U.S.A. (Department of the Air Force). A process of producing semiconducting titanium dioxide by subjecting titanium to the action of hydrochloric acid, air drying the metal, and oxidizing the metal to form titanium dioxide.

2,812,388 Two Way Repeaters—D. L. Thomas. Assignee: International Standard Electric Corporation. A two way repeater arrangement consisting of a west line, an east line, amplifiers for the two directions, and hybrid transformers coupling the amplifiers to the lines and two balancing networks.

2,812,390 Transistor Amplifier Circuit—A. J. Van Overbeek. Assignee: North American Phillips Co., Inc. A cascade connected amplifier circuit having a given frequency spectrum and a given frequency value.

2,812,393 Power Supply and Bias Arrangement for Push-Pull Transistor Amplifier—W. S. Patrick. Assignee: Zenith Corporation. A push-pull transistor amplifier energized alternately from a battery or an unregulated commercial power source.

2,812,436 Transistor Oscillator Circuit—A. J. Van Overbeek. Assignee: North American Philips Co., Inc. An oscillator circuit having a high oscillator frequency exceeding the high frequency limit of the transistor.

2,812,437 Transistor Oscillators—G. C. Sziklai. Assignee: Radio Corporation of America. A transistor switching circuit for generating sawtooth current waveforms in an inductive load with a reduced kick-back voltage appearing across the transistor.

2,812,445 Transistor Trigger Circuit—A. E. Anderson. Assignee: Bell Telephone Laboratories. A circuit that regeneratively translates signals in the form of recurrent pulses of light into recurrent electrical pulses whose wave shapes and amplitudes are constant regardless of variations above a threshold level of the intensity of the input light signals.

2,812,446 Photo Resistance Device—G. L. Pearson. Assignee: Bell Telephone Laboratories. A silicon semiconductive photoconductive element comprising a single crystal body having contiguous zones of *p-n-p* type conductivity, one zone having a thickness no greater than the order of the diffusion length of the minority carriers in that zone.

2,812,474 Control Circuit Employing Transistors—R. A. Henle. Assignee: International Business Machine Corporation. A transistor translator and amplifier circuit which will shift a square wave signal to a different voltage range and to a circuit portion having different impedance characteristics.

2,812,480 Method of Treating Semiconductor Devices and Devices Produced Thereby—S. G. Ellis. Assignee: Radio Corporation of America. A method of treating a body of silicon by maintaining the surface of the body in an oxygen free atmosphere and causing said surface to come in contact with iodine and bromine.

2,813,048 Temperature Gradient Zone Melting—W. G. Pfann. Assignee: Bell Telephone Laboratories. The process of joining two bodies of different materials by adhering said two bodies to a common layer of a third material that is soluble in at least one of the first two and causing heat to be applied and melting to take place so that a liquid solid interface progresses through the materials.

November 12, 1957

2,813,233 Semiconductive Device—W. Shockley. Assignee: Bell Telephone Laboratories. A high frequency junction transistor is built to give rise to a large recombination current in the emitter-base branch circuit by choice of material of appropriate lifetime for the various constituent zones.

2,813,244 Transistor Amplifier—S. W. Guggi. Assignee: Westinghouse Electric Corporation. A transistorized control system for coupling an *a-c* source to a load wherein compensation is automatically made for the variation of transistor characteristics with changes in the transistor operating temperature.

2,813,247 Phase Shifter for Motor Control Systems and the Like—R. O. Decker. Assignee: Westinghouse Electric Corporation. A phase shifting network for use in the control of 2-phase motors by variation of the power source frequency of the motor, said network maintaining a constant phase shift over a wide frequency range.

2,813,262 Electric Selector Device—A. Garde, E. Person. Assignee: Allmanna Svenska Elektriska Aktriebolaget (Sweden). An electric selector device for quantities able to be represented as *d-c* voltages, said device operating only with purely static members.

November 19, 1957

2,813,817 Semiconductive Devices and Their Manufacture—H. W. Leverenz. Assignee: Radio Corporation of America. A junction semiconductor device having uniform transit paths for current carriers flowing between emitter and collector regions.

2,813,934 Transistor Amplifier—C. A. Cibelius, Jr., D. K. Schaeve. Assignee: Barber-Colman Co. A high gain transistor amplifier in which there exists a linear relationship between the output and input signals, and in which the output is constant in spite of ambient temperature variations.

2,813,957 Semiconductor Device—J. B. Gosling. Assignee: General Electric Co. A cell comprising a body of fragile crystalline material having photoelectric and semiconductive properties, said cell being enclosed and imbedded in a vitreous material, with conducting leads attached to the cell and extending through the vitreous envelope.

2,813,976 Transistor Oscillator—G. C. Uchrin, W. O. Taylor. Assignee: United States of America (Dept. of the Army). A square wave oscillator including a pair of identical transistors in a push-pull configuration, a saturable transformer with a center tapped primary winding, a secondary, a center-tapped tertiary winding, a voltage source connected through the transformer to the base-collector electrodes of the transistors, and means connecting the tertiary winding between the base and emitter electrodes.

2,814,004 Electrically Semiconductive Object and Method of Producing Same—C. H. Goodman. Assignee: General Electric Company Ltd. A device comprising a semiconductive body including a chemical compound having the formula MNX_2 where M represents copper or silver, N stands for aluminum, gallium, indium, or thallium, and X represents sulphur, selenium, or tellurium.

November 26, 1957

2,814,589 Method of Plating Silicon—M. C. Waltz. Assignee: Bell Telephone Laboratories. A process of coating a silicon wafer with a gold-antimony layer, heating said wafer to form a gold-antimony-silicon bond, and electrolytically depositing a copper layer on the gold-antimony layer.

2,814,709 Manufacture of Dry Rectifiers—A. H. Walker. Assignee: Westinghouse Brake and Signal Co., Ltd. A method of manufacturing dry contact rectifier elements which includes removing short circuits between the counter electrodes and the base by passing a *d-c* pulse through the element in the forward direction.

2,814,735 Semiconductor Device—W. R. Cady, J. E. Mulhern, Jr. Assignee: General Electric Co. A semiconductor body has attached to it a source of voltage that establishes an electric field in the body, said field having a component transverse to the direction of the flow of holes established by another (*a-c*) source, said transverse component preventing the return of carriers to a junction thereby increasing the high frequency response of the device.

2,814,736 Linear Saw-Tooth Wave Generator—D. J. Hamilton. Assignee: Hughes Aircraft Co. A transistorized sawtooth wave generator that develops linear sawtooth current or voltage.

2,814,769 Electronic Power Supply and Clock Motor—R. Williams. Assignee: General Electric Co. Transistorized oscillatory electronic apparatus for energizing a single phase synchronous motor in a manner that causes the motor to start by itself.

2,814,773 Voltage Regulator—J. S. Comins, P. J. Gallagher. Assignee: Sorensen and Co., Inc. A voltage regulator that utilizes a bridge type sensing circuit containing Zener diodes.

2,814,780 Bridge Type Modulator Mixer—R. H. Edwards. Assignee: Engineering Laboratories, Inc. Apparatus for combining a carrier and an oscillator frequency without the use of transformers in order to deliver an output frequency.

December 3, 1957

2,814,852 Semiconductor Amplifiers and Transmitters—I. G. Cressell, M. F. Madigan, W. E. Cropsey. Assignee: Marconi's Wireless Telegraph Co. Ltd. A method of making a semiconductor amplifier by forming a *p-n* junction in a body of germanium, annealing said body, etching the body to form a shoulder at the junction, and placing one or more contact wires on the surface of the shoulder.

2,814,853 Manufacturing Transistors—E. Paskell. Assignee: Power Equipment Company. A method of manufacture in which standard production equipment can be used to obtain the required dimensional control and higher yield of acceptable transistors.

2,815,303 Method of Making Junction Single Crystals—C. G. Smith. Assignee: Raytheon Manufacturing Co. A method of making junction type crystals of silicon or germanium having predetermined concentrations of *p*-type and *n*-type doping elements, heating and maintaining the crystal at an elevated temperature, thus causing the concentration of the impurity having a high rate of evaporation to fall below the concentration of the other impurity element in the exterior layer of the crystal.

2,815,304 Process for Making Fused Junction Semiconductor Products—R. A. Gudmandsen. Assignee: Hughes Aircraft Co. A method of producing a germanium or silicon body of the fused junction type by contacting the body with a specimen that includes a solvent metal having a predetermined rate of evaporation below the melting point of the body, heating said body, maintaining the temperature, thus causing the formation of a regrown region separated from the parent body by a rectifying barrier.

2,815,472 Rectifier Unit—S. A. Jackson, C. E. Bacon. Assignee: General Electric Co. A rectifier unit having a cell that is provided with heat absorbing and cooling members which effectively increase its thermal mass and improve its thermal time constant.

2,815,473 Semiconductor Devices—T. A. Ketteringham, C. F. Machin. Assignee: The General Electric Co., Ltd. A device comprising a hollow block of high thermal and electrical conductivity, a rectifier element secured to a closed end of said block, a tubular member inside the block for providing passage of a cooling liquid therethrough.

2,815,474 Glass Sealed Semiconductor Rectifier—W. M. Lewis, Jr., H. D. Frasier. Assignee: Pacific Semiconductors, Inc. A sleeve for large electrode semiconductor diode packages.

2,815,475 Selenium Rectifier—P. E. Lighty. Assignee: International Telephone and Telegraph Corp. A polymonochlorotrifluorethylene lacquer is used as an artificial barrier layer for a selenium rectifier.

2,815,487 Signal Converter—A. B. Kaufman. Assignee: Northrop Aircraft, Inc. A signal converter utilizing the characteristic properties of semiconductor photodiodes to provide a unit having high input impedance and suitable for use with low to medium impedance devices developing an output voltage.

[To Be Continued]

CHARACTERISTICS CHARTS OF NEW DIODES and RECTIFIERS

ANNOUNCED BETWEEN DEC. 1, 1959 and JAN. 31, 1960 ONLY.

MANUFACTURERS

AEG— Allgemeine Elekticitats-Gesellschaft
AEI— Associated Electrical Industries, Ltd.
AMP— Amperex Electronic Corp.
AUD— Audio Devices, Inc.
BEN— Bendix Aviation Corp.
BER— Berkshire Labs
BOG— Bogue Electric Mfg. Co.
BOM— Bomac Labs
BRA— Bradley Labs
CBS— CBS Electronics
CDC— Continental Device Corp.
COL— Columbus Electronics Corp.
CTP— Clevite Transistor Products, Inc.
CSF— Compagnie Generale de T.S.F.
DAL— Dallons Semiconductor
DEL— Delco Radio
EEVB— English Electric Valve Co., Ltd.
ERI— Erie Resistor Corp.
FAN— Fansteel Metallurgical Corp.
FERB— Ferranti Ltd.
GAH— Gahagan, Inc.
GECB— General Electric Co., Ltd.
GE— General Electric Company, Semiconductor Div.
GELC— Canadian General Electric Co.
GIC— General Instrument Corp.
GTC— General Transistor Corp.
HAFO— Institutet for Halvedarforskning
HSD— Hoffman Semiconductor Division
HITJ— Hitachi Ltd., Mushashi Works
HUG— Hughes Products Division
INRB— International Rectifier Co., Ltd.
INRC— International Rectifier Corp.
IRC— International Resistance Co.
ITT— International Tel. & Tel. Corp.
KEM— Kemtron Electron Products, Inc.
LCTF— Laboratoire Central de Telecommunications
MAL— P. R. Mallory & Co., Inc.
MIC— Microwave Associates, Inc.
MIFI— Microfarad
MOT— Motorola, Inc.
MUL— Mullard, Ltd.
NAE— North American Electronics
NPC— Nucleonic Products Co., Inc.
OHM— Ohmite Manufacturing Co.
PHI— Philco Corp. Lansdale Tube Company
PLEB— The Plessey Co.
PSI— Pacific Semiconductors, Inc.
QSC— International Diode Corp.
RADF— La Radiotechnique, Div. Tubes Electroniques
RAY— Raytheon Company
RCA— Radio Corporation of America, Semiconductor Di
RHE— Rheem Semiconductor Corp.
ROSG— Dr. Ing. Rudolph Rost
SAR— Sarkes Tarzian, Inc., Rectifier Division
SCN— Semicon, Inc.
SEM— Semi-Elements Inc.
SIE— Siemens & Halske Aktiengesellschaft
SIL— Silicon Transistor Corp.
SONY— Sony Corp.
SSD— Sperry Semiconductor Division
SSP— Solid State Products, Inc.
STC— Shockley Transistor Corp.
STCB— Standard Telephone & Cables, Ltd.
SYL— Sylvania Electric Products, Inc.
SYN— Syntron Co.
TEX— Texas Research Assoc.
TFKG— Telefunken, Ltd.
TI— Texas Instruments, Inc.
TKD— Tekade, Nurnberg, Germany
TOK— Tokyo Tsushin Kogyo, Ltd.
TRA— Transitron Electronic Corp.
TUN— Tung-Sol Electric, Inc.
TSC— Trans-Sil Corp.
UCI— United Components
USD— United States Dynamics Corp.
USS— U. S. Semiconductor Products, Inc.
VIC— Vickers Inc.
WEC— Western Electric Co.
WEST— Westinghouse Electric Corp.

NEW DIODES and RECTIFIERS

TYPE NO.	USE (See Code Below)	MAT	PIV	MAX. CONT. WORK. VOLT.	Min. Forward Current @ 25°C I_f	@ E_f	MAX. D.C. OUTPUT CURRENT[4]	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4]	Max. Rev. Current I_b	@ E_b	@ T	MFR. (See code at start of charts)
			(volts)	(volts)	(mA)	(volts)	(amps)		(volts)	(uA)	(volts)	(°C)	
1G8	2	Si		100			.75	50A	1.0	.30	100	25	PLEB
1H2-2361	2	Si		4000			.05	100	6.0	100	4000	100	COL
1H3-2361	2	Si		5000			.05	100	6.0	100	5000	100	COL
1H4-2361	2	Si		6000			.05	100	6.0	100	6000	100	COL
1N897	1	Si	50	50	5.0	1.0				5.0	10	100	PSI
1N898	1	Si	50	50	100	1.0				5.0	10	100	PSI
1N899	1	Si	100	100	5.0	1.0				5.0	10	100	PSI
1N900	1	Si	100	100	50	1.0				5.0	10	100	PSI
1N901	1	Si	100	100	100	1.0				5.0	10	100	PSI
1N902	1	Si	200	200	10	1.0				5.0	10	100	PSI
1N909	7	Ge	60	50	10	.34-.37	.10	25A		10	10	25A	GIC
1N910	7	Ge	40	30	10	.34-.37	.10	25A		10	10	25A	GIC
1N911	7	Ge	30	20	10	.34-.37	.10	25A		10	10	25A	GIC
1N1696	2	Si		500			.60	50A	.60	500	500	100	GELC
1N1697	2	Si		600			.60	50A	.60	500	600	100	GELC
1N2054	2	Si	50	50			225	135B	.55	40ma	50	175B	INRC
1N2055	2	Si	100	100			225	135B	.55	40ma	100	175B	INRC
1N2056	2	Si	150	150			225	135B	.55	40ma	150	175B	INRC
1N2057	2	Si	200	200			225	135B	.55	40ma	200	175B	INRC
1N2058	2	Si	250	250			225	135B	.55	40ma	250	175B	INRC
1N2059	2	Si	300	300			225	135B	.55	40ma	300	175B	INRC
1N2060	2	Si	350	350			225	135B	.55	40ma	350	175B	INRC
1N2061	2	Si	400	400			225	135B	.55	40ma	400	175B	INRC
1N2062	2	Si	450	450			225	135B	.55	40ma	450	175B	INRC
1N2063	2	Si	500	500			225	135B	.55	40ma	500	175B	INRC
1N2793	2	Si	50	50			5.0	150C	1.25	5000	50	150	GIC
1N2794	2	Si	100	100			5.0	150C	1.25	5000	100	150	GIC
1N2795	2	Si	150	150			5.0	150C	1.25	5000	150	150	GIC
1N2796	2	Si	200	200			5.0	150C	1.25	5000	200	150	GIC
1N2797	2	Si	250	250			5.0	150C	1.25	5000	250	150	GIC

TYPE NO.	USE {See Code Below}	MAT	PIV	MAX. CONT. WORK. VOLT.	Min. Forward Current @ 25°C		MAX. D.C. OUTPUT CURRENT[4]	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4]	Max. Rev. Current			MFR. {See code at start of charts}
					I_f @	E_f				I_b @	E_b @	T	
			(volts)	(volts)	(mA)	(volts)	(amps)		(volts)	(uA)	(volts)	(°C)	
1N2798	2	Si	300	300			5.0	150C	1.25	5000	300	150	GIC
1N2799	2	Si	350	350			5.0	150C	1.25	5000	350	150	GIC
1N2800	2	Si	400	400			5.0	150C	1.25	5000	400	150	GIC
1T22	1	Ge	60	60	5.0	1.0				30	10	25	SONY
1T23	1	Ge	20	20	2.5	1.0				50	10	25	SONY
1T20105	2	Si	50	50			.75	50A	.90	720	50	150A	SONY
2G8	2	Si		200			.75	50A	1.0	.75	200	25	PLEB
2M4	2	Si		200			3.0	25	1.0	.20	200	25A	PLEB
3G8	2	Si		300			.75	50A	1.0	1000	300	25	PLEB
4G8	2	Si		400			.75	50A	1.0	1500	400	25	PLEB
4M4	2	Si		400			3.0	25	1.0	.20	400	25A	PLEB
5E5	1	Si	500	500	500	1.3				500		100	INRC
5E6	1	Si	600	600	500	1.3				500		100	INRC
5G8	2	Si		500			.75	50A	1.0	1750	500	25	PLEB
6F5	2	Si	50	35			6.0	25					INRC
6F10	2	Si	100	70			6.0	25					INRC
6F15	2	Si	150	105			6.0	25					INRC
6F20	2	Si	200	140			6.0	25					INRC
6F30	2	Si	300	210			6.0	25					INRC
6F40	2	Si	400	280			6.0	25					INRC
6F50	2	Si	500	350			6.0	25					INRC
6G8	2	Si		600			.75	50A	1.0	2000	600	25	PLEB
6M4	2	Si		600			3.0	25	1.0	.20	600	25A	PLEB
8G7	2	Si		800			.74	25A	1.0	3000	800	25	PLEB
10G4	2	Si		1000			.40	25A	1.5	10ma	1000	25	PLEB
12F5	2	Si	50	35			12	25					INRC
12F10	2	Si	100	70			12	25					INRC
12F15	2	Si	150	105			12	25					INRC
12F20	2	Si	200	140			12	25					INRC
12F30	2	Si	300	210			12	25					INRC
12F40	2	Si	400	280			12	25					INRC
12F50	2	Si	500	350			12	25					INRC
B205	2	Ge		30			10	25	.70	30ma	15	25	BEN
CD1121	2	Si		50			.20	25		100	35	100A	CDC
CD1122	2	Si		100			.20	25		100	70	100A	CDC
CD1123	2	Si		225			.20	25		.20	225	25	CDC
CD1124	2	Si		150			.20	25		100	105	100A	CDC
CD1125	2	Si		200			.20	25		100	140	100A	CDC
CD1126	2	Si		250			.20	25		100	175	100A	CDC
CD1127	2	Si		300			.20	25		100	210	100A	CDC
CD1141	1	Si		60	100	1.0	.20	25		1.0	60	150	CDC
CD1142	1	Si		125	100	1.0	.20	25		2.0	125	150	CDC
CD1143	1	Si		175	100	1.0	.20	25		2.0	175	150	CDC
CG50H	1	Ge	65	65	4.0	1.0	.03	25A		250	50	25A	AEI
CG60H	1	Ge	150	150	3.0	1.0	.03	25A	3.0	100	100	25A	AEI
CG61H	1	Ge	100	100	3.0	1.0	.03	25A	3.0	50	50	25A	AEI
CG62H	1	Ge	100	100	3.0	1.0	.03	25A	3.0	100	50	25A	AEI
CG63H	1	Ge	100	100	3.0	1.0	.03	25A	3.0	200	50	25A	AEI
CG64H	1	Ge	45	45	3.0	1.0	.03	25A	3.0	200	10	25A	AEI
CX5/25	5	Si	25				5.0	25A					AEI
CX5/50	5	Si	50				5.0	25A					AEI
CX5/75	5	Si	75				5.0	25A					AEI
CX5/100	5	Si	100				5.0	25A					AEI
CX5/150	5	Si	150				5.0	25A					AEI
CX5/200	5	Si	200				5.0	25A					AEI
CX5/250	5	Si	250				5.0	25A					AEI
CX5/300	5	Si	300				5.0	25A					AEI
CX10/25	5	Si	25				10	25A					AEI
CX10/50	5	Si	50				10	25A					AEI
CX10/75	5	Si	75				10	25A					AEI

NOTATIONS

Under Use

1. General Purpose
2. Power Rectifier
3. Magnetic Amplifier

Ø Insulated Base

5. Controlled Rectifier
6. Dual Rectifier

△ Direct Tube Replacement

7. Controlled Forward Conductance

Other

4. For half wave resistive load average over 1 cycle

Under Reverse Current

Ø Dynamic

Under Mfr.

6. Available in stack form from that manufacturer

Following any temperature reading these symbols apply

A — Ambient
C — Case
J — Junction
S — Storage
△ — Inlet Temperature of Coolant

Type No.

† — Revised Data

Manufacturers should be contacted for value and test condition for surge current and maximum peak recurrent current

Under E_f

Ø - at 125°C

NEW DIODES and RECTIFIERS

TYPE NO.	USE (See Code Below)	MAT	PIV	MAX. CONT. WORK. VOLT.	Min. Forward Current @ 25°C		MAX. D.C. OUTPUT CURRENT[4]	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4]	Max. Rev. Current			MFR. (See code at start of charts)
					I_f @	E_f				I_b @	E_b @	T	
			(volts)	(volts)	(mA)	(volts)	(amps)		(volts)	(uA)	(volts)	(°C)	
CX10/100	5	Si	100				10	25A					AEI
CX10/150	5	Si	150				10	25A					AEI
CX10/200	5	Si	200				10	25A					AEI
CX10/250	5	Si	250				10	25A					AEI
CX10/300	5	Si	300				10	25A					AEI
D1003	2	Si		100			30	25	1.5	20	100	25B	PLEB
D2003	2	Si		200			30	25	1.5	20	200	25B	PLEB
D4003	2	Si		400			30	25	1.5	20	400	25B	PLEB
ED1825	1	Ge		150	2.0	1.0				250	100	25	ERI
ED1892	1	Ge	20	15	8.0	1.0				200	10	25	ERI
ED1902	7	Ge	70	60	4.0-10	1.0				500	50	25	ERI
ED1980	1	Ge	50	40	50	1.0				50	30	25	ERI
ED2010	1	Ge	20	20	100	1.0				25	10	25	ERI
GEX542	2∅	Ge	160	160	8000	.55	6.0	35A	.50	25ma	160	70A	GECB
GJ3M	2	Ge	200	100			1.0	25A	1.0				AEI-6
GJ4M	2	Ge	75	100			1.0	25A	1.0				AEI-6
GJ5M	2	Ge	300	200			1.0	25A	1.0				AEI-6
GJ6M	2	Ge	150	200			1.0	25A	1.0				AEI-6
GW40	1	Ge	60	60	5.0	1.0				30	10	25	ROSG
GW60	1	Ge	70	70	2.5	1.0				200	50	25	ROSG
GW80	1	Ge	100	100	3.0	1.0				25	10	25	ROSG
GW103	1	Ge	20	20	5.0	1.0				20	10	25	ROSG
GW120	1	Ge	100	100	2.5	1.0				50	50	25	ROSG
HR14	2	Si		400			.30	75A		200	400	25A	HITJ
HR15	2	Si		500			.30	75A		200	500	25A	HITJ
HR24	2	Si		400			.30	75A		200	400	25A	HITJ
HR25	2	Si		500			.30	75A		200	500	25A	HITJ
HS30	2	Si		5000			.10	25A	20	10	5000	100A	FERB
HS31	2	Si		7500			.10	25A	25	10	7500	100A	FERB
HS32	2	Si		10000			.10	25A	30	10	10000	100A	FERB
HTS5A	2	Si	5000				.50	25A					AEI
HTS10A	2	Si	10000				.50	25A					AEI
MA70	1,2,3	Si	700	700	3000	.90	1.6	150	1.0	20	700	25A	TSC
MA80	1,2,3	Si	800	800	3000	.90	1.6	150	1.0	20	800	25A	TSC
MO5	1,2,3	Si	50	50	30000	1.0	25	150	1.0	5000	50	25A	TSC
MO10	1,2,3	Si	100	100	30000	1.0	25	150	1.0	5000	100	25A	TSC
MO15	1,2,3	Si	150	150	30000	1.0	25	150	1.0	5000	150	25A	TSC
MO20	1,2,3	Si	200	200	30000	1.0	25	150	1.0	5000	200	25A	TSC
MO25	1,2,3	Si	250	250	30000	1.0	25	150	1.0	5000	250	25A	TSC
MO30	1,2,3	Si	300	300	30000	1.0	25	150	1.0	5000	300	25A	TSC
MO40	1,2,3	Si	400	400	30000	1.0	25	150	1.0	5000	400	25A	TSC
MO50	1,2,3	Si	500	500	30000	1.0	25	150	1.0	5000	500	25A	TSC
MO60	1,2,3	Si	600	600	30000	1.0	25	150	1.0	5000	600	25A	TSC
MP5	1,2,3	Si	50	50	50000	1.0	35	150	1.0	5000	50	25A	TSC
MP10	1,2,3	Si	100	100	50000	1.0	35	150	1.0	5000	100	25A	TSC
MP15	1,2,3	Si	150	150	50000	1.0	35	150	1.0	5000	150	25A	TSC
MP20	1,2,3	Si	200	200	50000	1.0	35	150	1.0	5000	200	25A	TSC
MP25	1,2,3	Si	250	250	50000	1.0	35	150	1.0	5000	250	25A	TSC
MP30	1,2,3	Si	300	300	50000	1.0	35	150	1.0	5000	300	25A	TSC
MP40	1,2,3	Si	400	400	50000	1.0	35	150	1.0	5000	400	25A	TSC
MP50	1,2,3	Si	500	500	50000	1.0	35	150	1.0	5000	500	25A	TSC
MP60	1,2,3	Si	600	600	50000	1.0	35	150	1.0	5000	600	25A	TSC
MR5	1,2,3	Si	50	50	5000	.70	3.0	150	1.0	20	50	25A	TSC
MR10	1,2,3	Si	100	100	5000	.70	3.0	150	1.0	20	100	25A	TSC
MR15	1,2,3	Si	150	150	5000	.70	3.0	150	1.0	20	150	25A	TSC
MR20	1,2,3	Si	200	200	5000	.70	3.0	150	1.0	20	200	25A	TSC
MR25	1,2,3	Si	250	250	5000	.70	3.0	150	1.0	20	250	25A	TSC
MR30	1,2,3	Si	300	300	5000	.70	3.0	150	1.0	20	300	25A	TSC
MR40	1,2,3	Si	400	400	5000	.70	3.0	150	1.0	20	400	25A	TSC
MR50	1,2,3	Si	500	500	5000	.70	3.0	150	1.0	20	500	25A	TSC
MR60	1,2,3	Si	600	600	5000	.70	3.0	150	1.0	20	600	25A	TSC
MR70	1,2,3	Si	700	700	5000	.70	3.0	150	1.0	20	700	25A	TSC
MR80	1,2,3	Si	800	800	5000	.70	3.0	150	1.0	20	800	25A	TSC
MS70	1,2,3	Si	700	700	10000	.85	6.0	150	1.0	20	700	25A	TSC
MS80	1,2,3	Si	800	800	10000	.85	6.0	150	1.0	20	800	25A	TSC

TYPE NO.	USE (See Code Below)	MAT	PIV	MAX. CONT. WORK. VOLT.	Min. Forward Current @ 25°C I_f	@ E_f	MAX. D.C. OUTPUT CURRENT[4]	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4]	Max. Rev. Current I_b	@ E_b	@ T	MFR. (See code at start of charts)
			(volts)	(volts)	(mA)	(volts)	(amps)		(volts)	(uA)	(volts)	(°C)	
IT70	1,2,3	Si	700	700	12000	.80	12	150	1.0	100	700	25A	TSC
IT80	1,2,3	Si	800	800	12000	.80	12	150	1.0	100	800	25A	TSC
DA250	2	Si	50				14	100		5000	25	150	RADF
DA251	2	Si	100				14	100		4000	50	150	RADF
DA252	2	Si	200				14	100		2500	200	150	RADF
SJ051A	2	Si	50	50			1.5	25A	1.7	500	50	120J	AEI-6
SJ051B	2	Si	50	50			.70	25A	1.7	500	50	120J	AEI
SJ052A	2	Si	50	50			2.3	25A	1.7	1500	50	200J	AEI-6
SJ052B	2	Si	50	50			1.0	25A	1.7	1500	50	200J	AEI
SJ101A	2	Si	100	100			1.5	25A	1.7	500	100	120J	AEI-6
SJ101B	2	Si	100	100			.70	25A	1.7	500	100	120J	AEI
SJ102A	2	Si	100	100			2.3	25A	1.7	1500	100	200J	AEI-6
SJ102B	2	Si	100	100			1.0	25A	1.7	1500	100	200J	AEI
SJ201A	2	Si	200	200			1.5	25A	1.7	500	200	120J	AEI-6
SJ201B	2	Si	200	200			.70	25A	1.7	500	200	120J	AEI
SJ202A	2	Si	200	200			2.3	25A	1.7	1500	200	200J	AEI-6
SJ202B	2	Si	200	200			1.0	25A	1.7	1500	200	200J	AEI
SJ301A	2	Si	300	300			1.5	25A	1.7	500	300	120J	AEI-6
SJ301B	2	Si	300	300			.70	25A	1.7	500	300	120J	AEI
SJ302A	2	Si	300	300			2.3	25A	1.7	1500	300	200J	AEI-6
SJ302B	2	Si	300	300			1.0	25A	1.7	1500	300	200J	AEI
SJ401A	2	Si	400	400			1.5	25A	1.7	500	400	120J	AEI-6
SJ401B	2	Si	400	400			.70	25A	1.7	500	400	120J	AEI
SJ402A	2	Si	400	400			2.3	25A	1.7	1500	400	200J	AEI-6
SJ402B	2	Si	400	400			1.0	25A	1.7	1500	400	200J	AEI
SJ501A	2	Si	500	500			1.5	25A	1.7	500	500	120J	AEI-6
SJ501B	2	Si	500	500			.70	25A	1.7	500	500	120J	AEI
SJ601A	2	Si	600	600			1.5	25A	1.7	500	600	120J	AEI-6
SJ601B	2	Si	600	600			.70	25A	1.7	500	600	120J	AEI
SL101A	2	Si	100				10	30A					AEI-6
SL201A	2	Si	200				10	30A					AEI-6
SL301A	2	Si	300				10	30A					AEI-6
SL401A	2	Si	400				10	30A					AEI-6
SR2201A	2	Si	400				.70	25A					AEI
SR2301A	2	Si	600				.70	25A					AEI
SR4201A	2	Si	800				.70	25A					AEI
SR4301A	2	Si	1200				.70	25A					AEI
SR4401A	2	Si	1600				.70	25A					AEI
SR4501A	2	Si	2000				.70	25A					AEI
SX11	1	Si	60	60	100	1.5	.10	25A	1.0	5.0	60	100A	GECB
SX12	1	Si	120	120	100	1.5	.10	25A	1.0	5.0	120	100A	GECB
SX13	1	Si	180	180	100	1.5	.10	25A	1.0	5.0	180	100A	GECB
X16RC2	5	Si	20	20			16	30	.90	6500		30A	INRC
X16RC3	5	Si	30	30			16	30	.90	6500		30A	INRC
X16RC5	5	Si	50	50			16	30	.90	6500		30A	INRC
X16RC7	5	Si	70	70			16	30	.90	6500		30A	INRC
X16RC10	5	Si	100	100			16	30	.90	6500		30A	INRC
X16RC15	5	Si	150	150			16	30	.90	6500		30A	INRC
X16RC20	5	Si	200	200			16	30	.90	6500		30A	INRC
ZR30	2	Si		50			30	25A	1.2	2000	50	100A	FERB
ZR31	2	Si		100			30	25A	1.2	2000	100	100A	FERB
ZR32	2	Si		200			30	25A	1.2	2000	200	100A	FERB
ZR33	2	Si		300			30	25A	1.2	2000	300	100A	FERB
ZR34	2	Si		400			30	25A	1.2	2000	400	100A	FERB
ZR35	2	Si		500			30	25A	1.2	2000	500	100A	FERB
ZS8	1	Si		30	100	1.5				.05	30	100	FERB
ZS21	1	Si		200	100	1.5				5.0	200	100	FERB

NOTATIONS

Under Use

1. General Purpose
2. Power Rectifier
3. Magnetic Amplifier

Ø Insulated Base

5. Controlled Rectifier
6. Dual Rectifier

△ Direct Tube Replacement

7. Controlled Forward Conductance

Other

4. For half wave resistive load average over 1 cycle

Under Reverse Current

⍁ Dynamic

Under Mfr.

6. Available in stack form from that manufacturer

Following any temperature reading these symbols apply

A — Ambient
C — Case
J — Junction
S — Storage
△ — Inlet Temperature of Coolant

Type No.

† — Revised Data

Manufacturers should be contacted for value and test condition for surge current and maximum peak recurrent current

Under E_f

Ø – at 125°C

NEW DIODES and RECTIFIERS

The following manufacturers have announced that they have begun supplying the indicated previously registered diodes and rectifiers.

AMPEREX ELECTRONIC:
1N38A, 1N54A, 1N58,A, 1N60, 1N63, 1N67A, 1N68A, 1N89, 1N90, 1N95, 1N99, 1N116, 1N117, 1N119, 1N120, 1N126, 1N128, 1N191, 1N192, 1N198

CANADIAN GENERAL ELECTRIC:
1N34,A, 1N35, 1N38, 1N38A, 1N38B, 1N48, 1N51, 1N52, 1N52A, 1N54, 1N54A,1N58, 1N58A, 1N63, 1N65, 1N67, 1N67A, 1N68A, 1N69, 1N69A, 1N70, 1N70A, 1N75, 1N81, 1N81A, 1N90, 1N91, 1N92, 1N93, 1N116, 1N126, 1N1126A, 1N127, 1N1127A, 1N128, 1N151, 1N152, 1N153, 1N158, 1N198, 1N253 thru 1N256, 1N332 thru 1N337, 1N339 thru 1N346, 1N348, 1N349, 1N440 thru 1N445, 1N440B thru 1N445B, 1N456 thru 1N459, 1N456A thru 1N459A, 1N461 thru 1N464, 1N461A thru 1N464A, 1N482 thru 1N488, 1N482A thru 1N488A, 1N482B thru 1N485B, 1N536 thru 1N540, 1N547, 1N550 thru 1N555, 1N599 thru 1N614, 1N599A thru 1N614A, 1N636, 1N1095, 1N1096, 1N1100 thru 1N1103, 1N1115 thru 1N1120, 1N1487 thru 1N1492, 1N1692 thru 1N1695

CLEVITE TRANSISTOR:
1N456, 1N461 thru 1N464, 1N461A thru 1N464A, 1N482, 1N482B, 1N483, 1N483A, 1N483B, 1N484A, 1N484B, 1N485, 1N485A, 1N485B, 1N486A, 1N487, 1N487A, 1N488A, 1N629

COLUMBUS ELECTRONICS:
1N1444, 1N2154 thru 1N2159, 1N2154R thru 1N2159R, 1N2160, 1N2382, 1N2383

CONTINENTAL DEVICE:
1N722

DALLONS SEMICONDUCTOR:
1N2159

ELECTRON RESEARCH:
1N52A, 1N69A, 1N96A, 1N98, 1N98A, 1N99A, 1N100A, 1N111, 1N112, 1N270, 1N276, 1N281, 1N292, 1N456 thru 1N459, 1N461 thru 1N464, 1N482 thru 1N488, 1N497 thru 1N500, 1N645 thru 1N649, 1N772

GENERAL INSTRUMENT:
1N57, 1N66,1N67,1N68, 1N88,1N96A,1N97 thru 1N100, 1N107, 1N108, 1N116, 1N117, 1N118,1N132, 1N278, 1N287 thru 1N292, 1N294, 1N308, 1N312, 1N313, 1N316 thru 1N320, 1N323 thru 1N327, 1N359, 1N359A, 1N360 thru 1N363, 1N360A thru 1N363A, 1N429, 1N432, 1N434, 1N435, 1N447, 1N456A thru 1N459A, 1N461A thru 1N464A, 1N487, 1N488A, 1N488, 1N497 thru 1N502, 1N588, 1N589,1N631,1N632,1N633,1N636, 1N643A, 1N662A, 1N663A, 1N676 thru 1N679, 1N681 thru 1N689, 1N702 thru 1N745, 1N746 thru 1N759, 1N761 thru 1N769,1N778,1N779,1N789, 1N791, 1N792, 1N793, 1N795, 1N801, 1N802, 1N804 thru 1N809, 1N811 thru 1N815, 1N818, 1N846 thru 1N889, 1N1124 thru 1N1128, 1N1124R thru 1N1128R, 1N1133 thru 1N1149, 1N1143A, 1N1191 thru 1N1194, 1N1251 thru 1N1261, 1N1341 thru 1N1348, 1N1518 thru 1N1528, 1N1551 thru 1N1560, 1N1588 thru 1N1598, 1N1612 thru 1N1616, 1N1732, 1N1733, 1N1734, 1N1765 thru 1N1802, 1N1927 thru 1N1944, 1N2069 thru 1N2079, 1N2512 thru 1N2517, 1N2512R thru 1N2517R

HITACHI LTD.:
1N34A, 1N35, 1N38A, 1N56A, 1N60

HUGHES:
1N645, 1N646, 1N647, 1N648, 1N649

INTERNATIONAL RECTIFIER :
1N1487 thru 1N1492, 1N1183 thru 1N1198, 1N2154 thru 1N2160

INTERNATIONAL RECTIFIER LTD.:
This company is a subsidiary of International Rectifier (USA), and manufactures all types produced by International Rectifier.

MICROFARAD:
This company is licensed by Compagnie Generale de T.S.F. and manufactures all types produced by Compagnie Generale de T.S.F.

RAYTHEON:
1N248A, 1N249A, 1N250A, 1N270, 1N273, 1N276, 1N277, 1N281, 1N283, 1N1124 thru 1N1128, 1N1195, 1N1196, 1N1197, 1N1198, 1N1763, 1N1764

RHEEM SEMICONDUCTOR:
1N251, 1N252, 1N903, 1N904, 1N905, 1N906, 1N907, 1N908

SEMICON:
1N440 thru 1N444, 1N550 thru 1N555, 1N607 thru 1N614, 1N607A thru 1N614A, 1N1115 thru 1N1120, 1N1169, 1N1169A 1N1217 thru 1N1226, 1N1217A thru 1N1224A, 1N1227 thru 1N1236, 1N1227A thru 1N1234A, 1N1443, 1N1444, 1N2080 thru 1N2086, 1N2217, 1N2219, 1N2221, 1N2223, 1N2223A, 1N2225, 1N2225A, 1N2229, 1N2229A, 1N2231, 1N2231A, 1N2233, 1N2233A, 1N2235, 1N2235A, 1N2237, 1N2237A, 1N2239, 1N2239A, 1N2241, 1N2241A, 1N2243, 1N2243A, 1N2267, 1N2269, 1N2271, 1N2289 thru 1N2293, 1N2289A thru 1N2293A, S10, S40, S50, S55, S60

TEXAS INSTRUMENTS:
1N253 thru 1N256, 1N456A thru 1N459A, 1N547, 1N625 thru 1N629, 1N643, 1N662, 1N663, 1N658

TRANSITRON ELECTRONIC:
1N746, 1N747, 1N748, 1N749, 1N750, 1N751, 1N752, 1N753, 1N754, 1N755, 1N756, 1N757, 1N758, 1N759

TRANS-SIL:
1N1199 thru 1N1206, 1N1341 thru 1N1348, 1N1537, 1N1538, 1N1539, 1N1540, 1N1541, 1N1542, 1N1543, 1N1544

VICKERS:
1N1612, 1N1613, 1N1614, 1N1615, 1N1616

CHARACTERISTICS CHART of NEW TRANSISTORS

Announced between Nov. 1, 1959 and Dec. 31, 1959. This is a partial listing continued from March 1960 issue. See March 1960 issue for manufacturers' code.

TYPE NO.	USE (See Code Below)	TYPE (See Code Below)	MAT	Max. Ratings @ 25° C: P_c (mw)	DERATING °C/W	V_{CB}	V_{CE}	Typical Characteristics: $f_{\alpha\beta}$ (mc)	Gain: PARAMETER and (condition)	VALUE	MFR. See code at end of chart
CTP1729	5	PNPA	Ge	30W	2.5	80	70		h_{FE}:I_c-500ma	50	CLE
CTP1730	5	PNPA	Ge	30W	2.5	100	80		h_{FE}:I_c-500ma	50	CLE
CTP1731	5	PNPA	Ge	30W	2.5	40	38		h_{FE}:I_c-500ma	100	CLE
CTP1732	5	PNPA	Ge	30W	2.5	80	70		h_{FE}:I_c-500ma	100	CLE
CTP1733	5	PNPA	Ge	30W	2.5	100	80		h_{FE}:I_c-500ma	100	CLE
CTP1735	5	PNPA	Ge	30W	2.5	60	55		h_{FE}:I_c-500ma	50	CLE
CTP1736	5	PNPA	Ge	30W	2.5	60	55		h_{FE}:I_c-500ma	100	CLE
OC22	5	PNPA	Ge		.30		32	2.5	h_{fe}:I_E-1.0A	150	AMP
OC23	5	PNPA	Ge		.30		40	2.5	h_{fe}:I_E-1.0A	150	AMP
OC24	5	PNPA	Ge		.30		32	2.5	h_{fe}:I_E-1.0A	150	AMP
OC26	3	PNPA	Ge		1.0	32	32	.15	h_{fe}:I_E-1.0A	33	AMP
OC27	3	PNPA	Ge		1.0	32	32	.30	h_{fe}:I_E-1.0A	64	AMP
OC28	5	PNPA	Ge				60	.20	h_{fe}:I_E-1.0A	32	AMP
OC29	5	PNPA	Ge				32	.20	h_{fe}:I_E-1.0A	90	AMP
OC30	3	PNPA	Ge		7.5	32	32	.30	h_{fe}:I_E-100ma	35	AMP
OC35	5	PNPA	Ge				32	.20	h_{fe}:I_E-1.0A	50	AMP
OC36	5	PNPA	Ge				32	.20	h_{fe}:I_E-1.0A	70	AMP
OC46	5	PNPA	Ge	83		20	20	3.0	h_{fe}:I_E- 15ma	80	AMP
OC47	5	PNPA	Ge	83		20	20	5.5	h_{fe}:I_E- 15ma	200	AMP
OC53	1	PNPA	Ge	10		7.0	7.0		h_{fe}:I_E-.25ma	35	AMP
OC54	1	PNPA	Ge	10		7.0	7.0		h_{fe}:I_E-.25ma	55	AMP
OC55	1	PNPA	Ge	10		7.0	7.0		h_{fe}:I_E-.25ma	80	AMP
OC56	1	PNPA	Ge	10		7.0	7.0				AMP
OC60	1	PNPA	Ge	10		7.0	7.0	1.6	h_{fe}:I_E-.25ma	60	AMP
OC74	3	PNPA	Ge	550			20	1.5	h_{fe}:I_E-300ma	65	AMP
OC75	3	PNPA	Ge	125		30	30	.75	h_{fe}:I_E-3.0ma	90	AMP
OC79	2	PNPA	Ge	550			26	1.2	h_{fe}:I_E-300ma	42	AMP
OC80	5	PNPA	Ge	550		32	32	2.0	h_{fe}:I_E-600ma	85	AMP
OC139	5	NPN	Ge	100		20	20	3.5	h_{fe}:I_E- 15ma	45	AMP
OC140	5	NPN	Ge	100		20	20	4.5	h_{fe}:I_E- 15ma	75	AMP
OC141	5	NPN	Ge	100		20	20	9.0	h_{fe}:I_E- 15ma	150	AMP
OC200	2	PNP	Si	250			25	1.0	h_{fe}:I_E-1.0ma	20	AMP
OC201	2	PNP	Si	250			25	4.0	h_{fe}:I_E-1.0ma	30	AMP
OCP70	1	PNP	Ge	25			7.5				AMP
OD760	3∅	A	Si		10	60	40	.50	h_{FE}:I_C-100ma	15	AEG
ST4150	3,5	NPND	Si	5000		60	60		h_{FE}:I_c-500ma	25	TRA
TR508	5	PNPA	Ge	150		16	12	3.5	h_{FE}:I_C- 20ma	125	IND
XA121	4	PNPD	Ge	80	750	25		30	h_{fe}:I_c-1.0ma	60	AEI
XA122	4,8	PNPD	Ge	80	750	25		30	h_{fe}:I_c-1.0ma	60	AEI
XA123	4,8	PNPD	Ge	80	750	20		30	h_{fe}:I_c-1.0ma	60	AEI
XA126	4	PNPD	Ge	80	750	20		30	h_{fe}:I_c-1.0ma	60	AEI
XA151	5	PNPA	Ge	130	300	20	16	3.0∅†	h_{FE}:I_c- 50ma	20min	AEI
XA152	5	PNPA	Ge	130	300	20	16	5.5∅†	h_{FE}:I_c- 50ma	40min	AEI
XA161	5	PNPMe	Ge	150	300	13	12	40†	h_{FE}:I_c- 10ma	50	AEI
XA162	5	PNPMe	Ge	150	300	13	12	60†	h_{FE}:I_c- 10ma	50	AEI
XB121	5	PNPA	Ge	50		105	105		h_{FE}:I_c-5.0ma	60	AEI

NOTATIONS

Under Use

1 - Low power a-f equal to or less than 50 mw
2 - Medium power a-f > 50 mw and equal to or less than 500 mw
3 - Power > 500 mw
4 - r-f/i-f
5 - Switching and Computer
6 - Low Noise
7- Photo
8- Mixer
9- Local Oscillator

∅ - Revised Spec.

Under Type

A - Alloyed
D - Diffused or Drift
F - Fused
G - Grown
H - Hook Collector
M - Microalloy
Me - Mesa
O - Other
S - Surface Barrier
UNI - Unijunction Transistor
Y - Symmetrical
§ Tetrode

Under f_{ab}

* Maximum Frequency
\# Figure of Merit
△ $f_{\alpha e}$
∅ Minimum
† f_T = Gain Bandwidth Product $h_{fe} \times f_{hfe}$

Under P_c

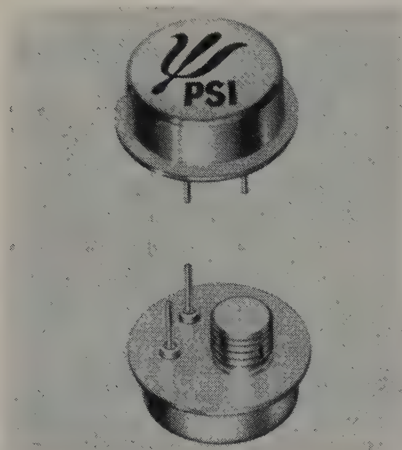
∅ - Infinite heat sink

New Products

Silicon Transistors

Pacific Semiconductors, Inc. announces two new very high power, high-frequency silicon transistors. These diffused, mesa transistors, designated as PT900 and PT901, are characterized by a power dissipation of 125 watts at 25°C case temperature; 50 mc alpha cut off frequency; 10 ampere continuous collector current and 0.2 ohm saturation resistance.

Circle 133 on Reader Service Card



Microwave Mixer Diodes

The Lansdale Division of Philco Corporation has announced the availability of the new IN78D silicon point-contact diodes in production quantities. They bring low-noise mixer performance to the Philco family of crystals specified for 16,000 mc first detector operation. Featuring a maximum conversion loss of 5.7 db and overall noise figure of 7.5 db, they are hermetically sealed and specified for operation up to 150°C. The series also features IF impedance range tightened to 400-565 ohms; RF impedance (VSWR) reduced to 1.5.

Circle 127 on Reader Service Card

Silicon Power Rectifiers

New military-type silicon power rectifiers, 1N1614, 1N1615, and 1N1616, have been designed by Bendix to meet military specifications MIL-E-1/1240, 1/1241, and 1/1242 respectively. Featuring a high reverse voltage characteristic ranging from 200 to 600 *Vdc*, the new rectifiers will operate at high temperatures with the low reverse current of one milliampere at 150°C. The new Bendix rectifiers are characterized by low forward voltage drop of 1.5 *Vdc* at 10 *Adc*.

Circle 116 on Reader Service Card

Temperature Test Chambers

The Electric Hotpack Company, Inc. announces a new line of hot-cold test chambers for environmental production testing of electronic components. Temperature range: −100° to +400°F. Six models, including a portable table top chamber with pull out drawer. Liquid CO_2 coolant provides rapid temperature drop . . . 107°F. to −70°F. in less than sixty seconds. High velocity fan insures rapid CO_2 dispersal.

Circle 120 on Reader Service Card

Transistorized Ultrasonic Cleaner

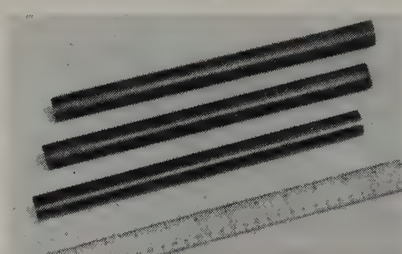
Narda Ultrasonics Corporation has introduced an economical small-size transistorized cleaner, called the UniBlast. The transistorized circuit receives about 40 watts of dc imput and produces about 30 watts of 65 kc output. It plugs into an ordinary 110-120 volt circuit, thus requires no special power lines. Transistorization has made it possible to bring ultrasonic cleaning within the means of vast market groups. Compactness and unitary design make the unit ideal for industrial production lines where small items must be cleaned before, during and after installation.

Circle 100 on Reader Service Card

Silicon Rods

Trancoa Chemical Corporation has announced the availability of polycrystalline silicon rods for floating zone crystal growing. The rods are centerless ground from silicon that has not been previously melted. As a result, they are very uniform in diameter, have a very low boron content and a density very near theoretical limits. The rods are offered in standard diameters of ¾″ and ⅞″ with tolerances of plus or minus .005 inches.

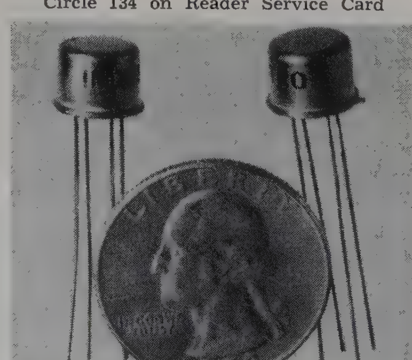
Circle 107 on Reader Service Card



Miniature Reference Amplifier

A miniature reference amplifier known as Mini Ref-Amp, has been announced by Industro Transistor Corporation. It is about the size of the eraser in the common lead pencil, and consists of a bipolar Zener diode (voltage reference) and a silicon amplifying transistor manufactured as one unit, and packaged in the TO-5 transistor case. About four components used in ordinary reference amplifiers are eliminated with this configuration. Reduction of components and unit packaging effectively reduces the temperature coefficient of practical regulator circuits.

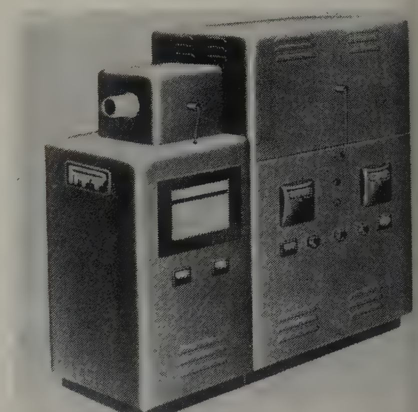
Circle 134 on Reader Service Card



Diffusion Furnaces

A new line of diffusion furnaces fo[r] semiconductor manufacturers, featurin[g] longer constant temperature work zone[s] is announced by Pitt Precision Product[s] Inc. These furnaces can be supplie[d] with as much as three continuous bu[t] independently controlled zones: (1) low temperature pre-heat zone to permit pre-heating of furnace load; (2) high tem[-]perature diffusion zone; (3) low tempera[-]ture source zone for use where lowe[r] diffusant source temperatures are re[-]quired. Other design features includ[e] the use of high purity impervious alum[i]na muffles to minimize contaminatio[n], economy, flexibility of control, conserva[-]tive insulation.

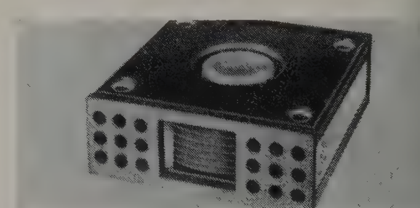
Circle 136 on Reader Service Card



Air Cooled Heat Exchanger

A new line of Forced Air Heat Exchangers has been developed by Gasket Mfg. Co., for cooling power transistors. Designed to operate from a ducted source of air, flowing at rates of from one to fifteen cfm, at standard conditions, these exchangers enable a 50 watt transistor to produce up to 50 watts. These Heat Exchangers are available in five models to fit all makes of power transistors.

Circle 111 on Reader Service Card



Evaporator System

A High Vacuum Evaporator System featuring a built-in flange that permits attachment to a controlled atmosphere enclosure has been developed by Temperature Engineering Corporation. Consists of a stainless steel evaporator chamber 12″ in diameter by 18″ long with a 5″ diameter pyrex viewport, a complete four inch high vacuum pumping system for vacuums to .01 microns or less, electrical controls, vacuum gauges, and a two KVA low voltage filament power supply.

Circle 135 on Reader Service Card

Transistor Transformers

Microtran Company, Inc., announces the availability on special order, of its catalog line of subminiature size transistor transformers in mu metal construction. Use of mu metal, in place of steel cans provides hum pick-up reduction of approximately 20-30 db. Available in MIL-AF construction ¾″ square by 1 ⅛″ high or in cylindrical construction $^{15}/_{16}$″ diameter by $^{15}/_{16}$″ high.

Circle 106 on Reader Service Card

licon-Carbide Rectifier

Development of commercially-available licon-carbide rectifiers has been reorted by Transitron Electronic Corpotion. Transitron engineers state that e new rectifiers represent a major reak-through in high temperature, radiion-resistant semiconductors. They can ithstand temperatures of 500°C. Will ermit reliable operation at temperatures n excess of 200°C. Typical reverse currents are less than 100 ua @ 50 volts at 0°C.

Circle 108 on Reader Service Card

entrifugal Transfer Pump

A new type of centrifugal pump speifically designed for transferring corroive liquids and solvents without leakage s being offered by Sethco Manufacturing Corp. Called El-10, it features a pump which is inside the motor housing and is nagnetically driven by the motor. Maxinum flow with water is 20 gallons per ninute. Maximum head developed is 25 eet. Liquids can be handled up to speific gravities of 1.5. Maximum working ressure is 150 psi.

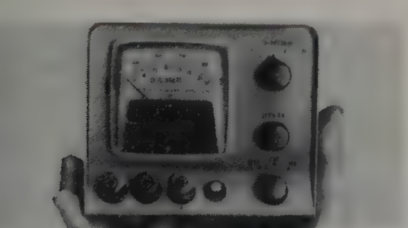
Circle 126 on Reader Service Card

ransistorized Power Supply

Electronic Research Associates, Inc. anounces the availability of a new compact ransistorized power supply which proides highly regulated continuously varible output for all battery voltage ranges.

Operating specifications include the folowing: Input voltage 105-125 VAC, 60 or 00 cps, Output 4-36 VDC at 0-500 ma, ine Regulation less than 0.15% change in utput for full input change, Load Reguation less than 0.05% no load to full load, Ripple less than 2 millivolts.

Circle 118 on Reader Service Card



acuum Furnace

Marshall Products Company has announced availability of a new high vacum furnace, known as the Model 58-HD, for making hardness tests at temeratures up to 3000°F. Heating element s a cylinder of sheet molybdenum 3" I. D. by 12-¾" long. Other features include: oading mechanism entirely within the acuum system to eliminate external rror, indentor movement so that hardess impressions may be made on three ifferent reference circles, 360° rotation of nvil and stage for maximum number of mpressions without breaking the vacuum.

Circle 109 on Reader Service Card

Precision Switch

The new KLIXON AT1-1 ("aspirin tablet") hermetically sealed Precision Switch weighing less than 1/28th of an ounce, has been introduced by Spencer Products, Metals & Controls Division of Texas Instruments Incorporated. Current capacity is 3 amperes, 28 volts *d-c* resistive. Ambient temperature range is −65°F to +275°F. (Shown at left enlarged 3 times; at right actual size.)

Circle 110 on Reader Service Card

Heating Unit

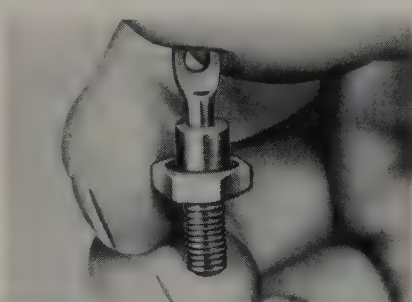
A new dual frequency 10 KW output high frequency induction heating unit (Model LI-10D-1) operating at approximately 400 KC and 4 MC is being offered by Lindberg Engineering Company. This unit has been specially designed for research and development work and for production of semiconductor and other conductive materials. Power input is 230/460 volts, 3 phase, 60 cycles. Other voltages and frequencies can be supplied.

Circle 122 on Reader Service Card

Silicon Power Rectifier

A new, double diffused Silicon Power Rectifier has been developed by Syntron Company. Officials describe the Style 21 as being rated at 13 amperes average at 25°C. ambient on a 3" x 3" x 1/16" copper heat sink. Standard and reverse polarity are achieved through the double diffusion. Typical forward dynamic resistance is .009 ohms.

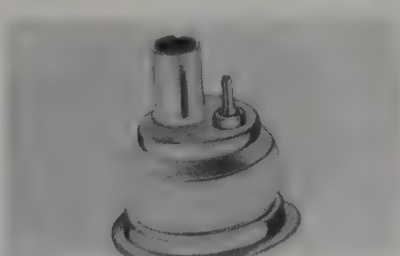
Circle 124 on Reader Service Card



Controlled Rectifier Housings

The development of a rugged, compact, high current, hermetically sealed controlled rectifier housing constructed of materials and processes to withstand temperatures above soft solder range and involving five seals to dissimilar materials has been announced by Mitronics, Inc. Designed and produced for a leading manufacturer of electrical and electronic original equipment, the mechanical requirement dictated the use of three metals: alloy "52, OFHC and Gr "A" Ni. A braze material to withstand temperatures above 1435°F was used.

Circle 130 on Reader Service Card



Utility Oven

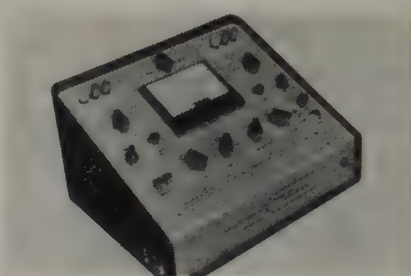
Blue M Mechanical Recirculating Electric Utility Ovens effectively use turboblower, heavy-duty motor and Blue M designed mounting, permiting vibrationless recirculating vertical airflow. Dependable Power Selector Switch controls wattage input for low, medium, or high temperatures. Temperature Range: 37.8°C to 260°C (500°F.) Automatic Hydraulic Thermostat has response sensitivity of ±½°C.

Circle 101 on Reader Service Card

Beta Transistor Tester

Development of a new, versatile dynamic Beta transistor tester, Model 870, has been announced by the Hickok Electrical Instrument Company. The tester measures large signal *d-c* Beta on power transistors as well as small signal *a-c* Beta on low and medium power transistors. Collector test current is variable up to 2 amperes, permitting Beta measurement of power transistors rated 5 amperes and more. Provides low voltage, high current tests, excellent for switching transistors.

Circle 102 on Reader Service Card



Induction Heater

The introduction of advanced design 3 megacycle induction type heaters has been announced by Sherman Industrial Electronics. Permitting instantaneous, pin-point heat with no contamination and no preheating, these heaters allow the rapid processing of diodes, transistors, semiconductors and other miniature components. All units are designed for use on regular factory voltages of 220 or 440 volts and special features include shock-proof, instant change coils and built-in current transformer.

Circle 113 on Reader Service Card

Microwave Diodes

Two new broadband video detector microwave diodes, covering the 10 to 20 kmc frequency band, have been made available by Sylvania for use in counter-measures equipment, microwave link systems, and similar applications. Type D-4104 has a minimum tangential signal sensitivity of minus 40 dbm and a minimum figure of merit of 15. Type D-4104A has a minimum sensitivity of minus 45 dbm and a minimum figure of merit of 30. Both diodes use a non-tripolar coaxial package and have a maximum video impedance of 18,000 ohms.

Circle 115 on Reader Seirvice Card

Drying Equipment

A new line of drying equipment for compressed air, or other gases, has been announced by the Pittsburgh Lectrodryer Division of McGraw-Edison Company. The series has been designated "Type BZ." Planned particularly for instrument air service, BZ Lectrodryers feature simplicity and modern, functional design. Parts are interchangeable, and the few moving parts are easily accessible, simplifying maintenance. Operation is completely automatic.

Circle 114 on Reader Service Card

(Continued on page 78)

Market News

(from page 25)

December 31, 1959 totalled $509,700 equivalent to 68 cents a share. This is an increase of 45% over net income for the comparable period the previous year when net income totalled $352,400. Since the company was not publicly owned at that time, per share earnings are not reflected.

Net sales for Accurate Specialties Co., Inc. and its subsidiaries for the six months ending December 31, 1959, were $539,500 compared to $255,700.00 for the same period a year ago. Net profit after taxes for this period amounted to $22,000.00 or earnings of 7¢ per share based on 329,600 shares outstanding. The company also reports an unfilled order backlog of $230,000.00 compared to $90,000.00 a year ago.

Directors of International Business Machines Corporation declared a regular quarterly cash dividend of $.75 per share on the common stock, payable March 10, 1960, to holders of record February 10, 1960. The former quarterly dividend rate was $.60 per share.

Sales

The Department of Defense has recently reported that purchases of transistors for military electronics for the first half of 1959 were greater than for the entire year of 1958.

1958	$37,190,000
1959 (first half only)	$41,300,000

EIA has released the following chart comparing transistor sales from January through November 1959 with that period in 1958:

1959	*Units*	*Dollars*
January	5,195,317	13,243,224
February	5,393,377	15,550,056
March	6,310,286	18,117,560
April	5,906,736	16,864,049
May	6,358,097	19,007,293
June	6,934,213	18,031,593
July	6,030,265	15,618,315
August	7,129,696	18,054,138
September	8,652,526	20,851,290
October	8,710,913	22,109,748
November	7,846,500	22,742,525
Total	74,467,926	$199,189,791

1958	*Units*	*Dollars*
January	2,955,247	6,704,383
February	3,106,708	6,806,562
March	2,976,843	6,795,427
April	2,856,234	7,025,547
May	2,999,198	7,250,824
June	3,558,094	8,262,343
July	2,631,894	6,598,762
August	4,226,616	9,975,935
September	5,076,443	10,810,412
October	5,594,856	13,461,857
November	5,440,981	12,441,759
Total	44,423,144	$96,133,811

Expansion

Sperry Rand Corp. has paid $415,000 for a 28 acre tract on Main Ave., Norwalk, Conn., on which they plan to build a new plant for their semiconductor division.

Ferranti, Ltd., of Manchester, England, has entered the transistor market with development of a double diffused mesa silicon transistor. By midyear they expect to reach an annual rate of production of 25,000 units. These transistors will be marketed in the United States through Ferranti Electric, Inc., N.Y.

Taihei Denshi K.K., Tokyo, an electronics firm is planning to build a 36,000 square foot plant in the suburbs of Tokyo for the production of germanium diodes. The plant is expected to be completed in October and will then have a capacity of about one million units per month.

Allegheny Electronic Chemical Co., Bradford, Pa., has begun a 33,000 square foot expansion of its silicon single crystal production facility. Full operation of this increased facility is expected this month.

Erie Resistor Corp. has established the Electron Research Inc., a wholly owned subsidiary to take over the work of its semiconductor division. Their current production consists of 37 standard and 20 special glass-packaged germanium diodes.

A line of 412 different Germanium transistor types is now available from the newly-formed Electronic Transistors Corp., North Bergen, New Jersey. The 412 Germanium transistor types are being manufactured under a patent license agreement with the Western Electric Company. Electronic Transistors Corp. will manufacture, in addition to Germanium transistors, a complete line of silicon transistors. All conform to applicable MIL specification. They will also produce power transistors in both semiconductor materials. Sales representatives have been established in metropolitan New York, Northern New Jersey, Southern New Jersey, Eastern Pennsylvania, Delaware, Maryland, the District of Columbia, Virginia, Minnesota, Wisconsin, Southern California and Arizona. In addition, sales representatives, to cover the entire United States, are now being considered and will be appointed in the near future.

Sperry Semiconductor has announced the appointment of Avnet Electronics Corporation, Westbury, New York as its exclusive distributor of all product lines in a 37-state area covering all states East of the Rockies.

Distribution

British import restrictions of American transistors have been lifted.

Ratheon Co. has moved its New York bury, Conn., has named sales representatives in Philadelphia, Minneapolis, Syracuse, Newtown (Conn.) and Chelmsford (Mass.)

Raytheon Co. has moved its New York City regional commercial sales staff from New York City to Englewood Cliffs, N.J.

Rheem Semiconductor Corp. has established a district sales office in Englewood, N.J.

According to the Finance Ministry, shipment of Japanese transistors to the United States in 1959 was approximately 2,393,000 units as compared with 10,620 in 1958. The shipment during the last quarter of 1959 dropped to 565,000 units, compared with about 1 million units during the previous quarter.

Government Contracts

Kemtron Electron Products, Inc., Newburyport, Mass.

Semiconductor Device, MIL Type 1N23 WE in a/w MIL-E-1117 dtd 14 Oct 195 and Spec MIL-E-1D dtd 31 Mar 58 an Amend #1 dtd 29 Oct 58 S/N 5960-615 4309, IFB 33-604-60-31 - - - - 27000 ea - - - $210600.

No. American Electronics, Inc., Lynn Mass., $5,068.07 for 2 vary. items of semiconductor devices: Type 1N1355, IFB 654.

Sylvania Electric Prods., Inc., Woburn Mass., $25,247.20 for 3 varying items of semiconductor devices. Sil. diode rectifier type IN23WC. IFB-480.

Texas Instruments Inc., Dallas, Te Transistor, silicon, Type 2N118 in a/ MIL-T-1950012 dtd 12 Dec 57—S/N 596 553-7016 - - - 5700 ea. - - - IFB 33-604-60-3 - - - $50103 Transistor, silicon, Typ 2N339, S/N 5960-630-5884, 1975 ea. - - Transistor, silicon. Type 2N332, S/N 5960 630-5882, 4030 ea.

A split award to General Electric Liverpool, N. Y., $160.00 for 1 item o transistors: Type 2N321; Texas Instr. Dallas, Tex., $478.00 for 1 item; Sterling Electronics, Inc., Houston, Tex., $12,881.2 for 1 item; North American Electronics Lynn, Mass., $825,000 for 1 item: Raytheon Co., Needham, Mass., $525.00 for 1 item. IFB-622,

A split award to Philco Corp. Lansdale Tube Co., div., Lansdale, Pa., $4,760.75 fo 2 varying items of transistors: Typ 2N495; Texas Instruments, Dallas, Tex $3,783.50 for 1 item; Hughes Prods., Newport Beach, Cal., $1,786.10 for 1 item IFB-595.

A split award to U. S. Semiconductor Prods., Phoenix, Ariz., $258.50 for 1 item of semiconductor devices: type 1N1365 No. American Electronics, Inc., West Lynn, Mass., $3,250.00 for 2 varying items Rheem Semiconductor Corp., Mountain View, Cal., $1,060.40 for 1 item; Continental Device Corp., Hawthorne, Cal. $2,565.00 for 1 item. IFB-584.

Pacific Semiconductors, Inc., Culver City, Cal., for 400 engineering test mode transistors and technical reports: $120,025

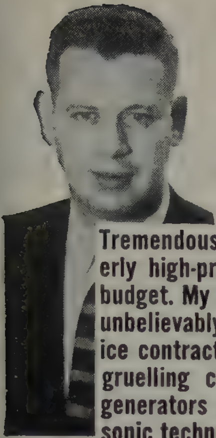
APPLICATIONS

[*From page 59*]

(*Fig. 35.2*). Up to the point marked (1), this is just the old IBM "Y" circuit The cathode follower has been added because of the difficulties found in attempting to correlate readings made by different users and manufacturers; for example, minor differences in the length of the cable connecting the tester to the oscilloscope caused significant differences in recovery time measurements.

Probably the most "accurate" recovery time tester is the Bureau of Standards circuit, which has been modified (Pacific Semiconductors, Inc.) as indicated in the simplified schematic (*Fig. 35.3*). This circuit avoids the problems associated with the use of clamping diodes by the simple expedient of reversing the diode so that the forward pulse drives the triode into cut-off; unfortunately there are other problems with this circuit.

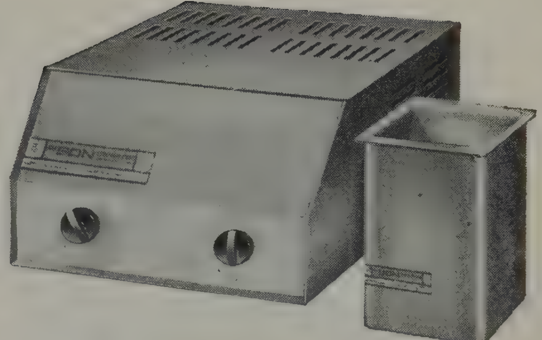
[Circle 200 on readers service card]



My name is Paul M. Platzman,

I pioneered the ultrasonic industry. Two well known ultrasonic companies were founded by me. Now, I have created a new organization, Ultrasonic Industries, Inc., based on a revolutionary approach to mass producing and selling ultrasonic equipment. No middleman's profit in this factory — direct-to-you deal.

Tremendous savings are passed on to you the customer bringing formerly high-priced ultrasonic cleaners within the range of everybody's budget. My products stand out because of their distinctive appearance, unbelievably low money-back-guaranteed prices—free five year service contract, and consistent trouble free performance under the most gruelling conditions. This is possible because my DiSONtegrator generators and transducers incorporate the latest advances in ultrasonic technology.



$99.95

Including tank, connecting cable and instruction manual (export model: 220V — 50 cycles $7.50 extra)

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ULTRASONIC CLEANER

Not Pint Size . . . But Full ½ gal cap.

The lowest priced ultrasonic cleaner ever sold! Buy ONE or 100 and Save!

The DiSONtegrator System Forty ULTRASONIC CLEANER is attractively styled, ruggedly-built, and work-tested to give a lifetime of trouble-free service.

The DiSONtegrator Features:

Simplified one knob control for easy operation. High Frequency sound waves disintegrate harmful soils and contaminants in seconds.
Saves time and labor, boosts production rate, improves product. You can replace hazardous chemicals with safe solvents and even water.

The DiSONtegrator works FAST

In SECONDS you can disintegrate soils on: radioactive lab apparatus; glassware; medical instruments; test tubes, syringes, hypodermic needles; dental instruments, drills, burrs, false teeth, bridges; fossils and fossil foraminifera; electronic components, semi-conductors, crystals, switches, precision potentiometers; optical parts, lenses, plastic contact lenses, eyeglasses; timing mechanisms; small gear trains; miniature printed circuit boards; and hundreds of other items.

In seconds you can remove:

rust, oxides, shop dirt, dust, lint, preservatives, finger prints, machining chips, extrusion lubricants, paraffin, wax, paint, varnish, lacquer, plastic residue, resists, silicones, greases cooked food residue, blood, plaster of paris, lapping compounds, carbon, radioactive particles, polishing compounds, shale, diatomite, volcanic tuffs, clay and sand, graphite, starches, cutting oils, heat treat scale, color stains, foundry sand, abrasives, quenching oil, salts, pitch, asphalt, tar, inks, adhesives, jewelers rouge, tripoli, resin flux, acid flux, many others.

The DiSONtegrator is VERSATILE

In addition to super speed, surgical precision cleaning it can be used to: brighten, quench, degrease, impregnate, decontaminate, pickle, etch, dip coat, emulsify, degas liquids, anodize, dye, mix, accelerate reactions.

Ultrasonic cleaners are widely used

in production lines, maintenance departments and laboratories. You should have at least one DiSONtegrator if your field is Electronic, Optical, Glass, Clinical, Biological, Textile, Oil, Food, Paper, Dental, Plastic, Drug, Rubber, Wood, Chemical, Isotope, Geological, Agronomical, Metallurgical, Anthropological, Paleontological, Petrochemical, Ceramics, Dairy, Brewery, Beverage, Confectionery, Laboratories, Photographic, Paint, Bottling, Cosmetic, Pharmaceutical, Metal Working, Metal Finishing, Die-Casting, Foundry, Plating, Metal Treating, Automotive, Aircraft, Horological, Jewelry, Medical, Marine, Mining, Utilities, Power Plants, Instrumentation.

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Guarantee

The DiSONtegrator you have just received is the finest ultrasonic machine made. It has passed a rigid inspection and found to be in perfect condition. Read your instruction manual carefully. Properly handled, this equipment will exceed your expectations and render long service.
A free 5 year service policy is included with this purchase. No charge for replacement parts first two years. Tubes carry 90 day guarantee. Service and parts required after the expiration of the guarantee will be furnished at prevailing factory prices.

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We will pay all shipping charges to any point within the continental limits of the United States (not including Alaska and Hawaii), if you enclose check with order.*

UNPRECEDENTED FREE 5 YEAR SERVICE CONTRACT

The DiSONtegrator — System Forty is available from stock for immediate delivery in unlimited quantities.

SPECIFICATIONS

GENERATOR INPUT: 117 V, 60 cycle — **GENERATOR OUTPUT:** 40 W, 90 KC
DIMENSIONS: GENERATOR: 10" L x 7" W x 5¾" H
Tank (overall): 6½" L x 7" W x 6½" H
Tank (inside): 5¼" L x 5¾" W x 4" D
Tank (capacity): 0.5 gal.

FOR THE FIRST TIME — you have a choice of 7 beautiful decorator colors to harmonize with your office or laboratory decor: Ivory, Wheat yellow, Turquoise, Desert sand, Pale green and Soft gray, and Coral pink. Please specify color when ordering.

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Gentlemen: Please ship ________ DiSONtegrator® System Forty Unit(s) @ $99.95 ea.: ☐ Ivory ☐ Wheat yellow ☐ Turquoise ☐ Desert sand ☐ Pale green ☐ Soft gray ☐ Coral pink

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I understand that my money will be refunded if not completely satisfied after 5 day trial.

☐ check enclosed (freight prepaid) ☐ C.O.D.
☐ bill me (rated firms only) ☐ Please put us on your mailing list

Circle No. 31 on Reader Service Card

Industry

CONFERENCE CALENDAR

The Following May 1960 Meetings Are Scheduled:

May 1-5 Electrochemical Society Meeting, La Salle Hotel, Chicago, Ill.

May 2-3 Company Member Conference, American Standards Association Spring Meeting, Sheraton Hotel, Philadelphia, Pa. For information: Henry G. Lamb, Secy., Company Member Conference, American Standards Assoc., 10 East 40th Street, New York 16, N. Y.

May 2-4 AIEE Northeastern District Meeting, Providence, R. I.

May 2-5 URSI-IRE Spring Meeting, Sheraton Hotel, Washington, D. C. Sponsored by URSI, PGCT, PGAP, PGI, PGMT&T, PGIT. For Information: Mrs. Helen E. Hart, URSI, USA Nat'l Committee, 2101 Constitution Avenue, Washington 25, D. C.

May 3-5 Western Joint Computer Conference, Fairmount Hotel, San Francisco, California. Sponsored by PGEC, AIEE, ACM. For Information: H. M. Zeidler, Stanford Research Institute, Computer Tech. Lab, Engrg. Division, Menlo Park, Calif.

May 6-7 2nd Annual Bay Area Reliability Seminar, Naval Post Graduate School, Monterey, California. Sponsored by IRE, PGR & QC. For Information: C. Bruce Clark, Stanford Research Institute, Menlo Park, Calif.

May 9-12 Instrument—Automation Conference & Exhibit, Brooks Hall, San Francisco, Calif. Sponsored by ISA.

May 10-12 Electronic Components Symposium, Hotel Washington, Washington, D. C. Sponsored by PGCP, AIEE, EIA, WEMA. For Information: Gilbert Devey, Sprague Electric Co., North Adams, Mass.

May 16-18 Electronics Parts Distributors Annual Show, Conrad Hilton Hotel, Chicago, Ill.

May 18-20 Electronic Industries Association Annual Convention, Pick-Congress Hotel, Chicago, Illinois.

May 23-25 7th Regional Technical Conference & Trade Show, Olympic Hotel, Seattle, Wash. Sponsored by Region 7. For Information: Dr. Frank Holman, Boeing Airplane Co., 10708 39th Ave., S.W., Seattle 66, Wash.

News . . .

ay 23-25 9th Nat'l Telemetering Conference, Miramar Hotel, Santa Monica, Calif. Sponsored by ISA, AIEE, ARS, IAS.

ay 23-26 Design Engineering Conference & Show, Statler-Hilton Hotel, New York City. Sponsored by ASME.

ay 25-27 Armed Forces Communications & Electronics Association, 14th Annual Convention, Sheraton-Park Hotel, Washington, D. C.

ay 25-27 Industrial Communications Association Annual Convention, Hotel Seville, Miami Beach, Florida.

ESEARCH & DEVELOPMENT

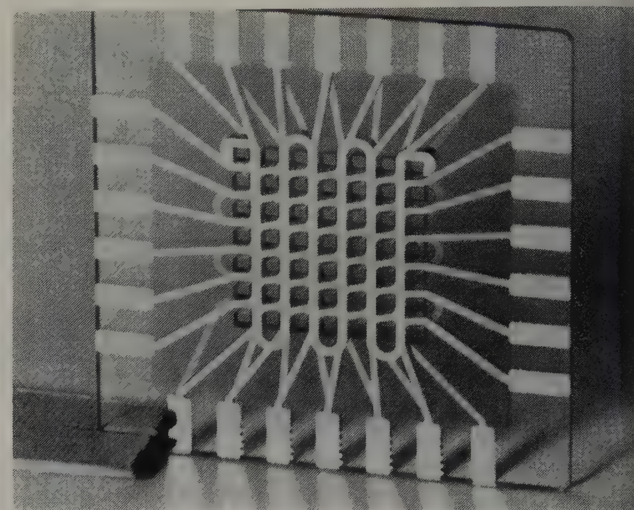
The Electronic Transistors Corp. has developed multi-eaded transistors to effect a further sub-miniaturization transistorized circuits. The multi-headed transistor is combination of any type or types of transistors presently use. These combinations, for example, may include NP, NPN, Audio Frequency, Amplifier, Computer, Con-erter, General Purpose, High Frequency, Low Frequency, ntermediate Frequency, Low Noise, Matched Pair, edium Frequency, Mixer, Oscillator, Radio Frequency, ub-miniature and Switching. These applications may be ombined in every variation and combination desired as ach multi-headed transistor contains the individual tran-stor as per specifications in the multi-headed package. he combination of these individual transistors within the ulti-headed package creates no interference and has no ontact with any other transistor within the package. pplications run from computers to missiles, aircraft, eophysical use, entertainment, medical science, and hear-g aids.

Arthur L. Chapman, president of CBS Electronics, the anufacturing division of Columbia Broadcasting System, nc., disclosed recently that they have been engaged for ver a year in developing space-age products for the ital new field of microelectronics. Mr. Chapman said, The scope of the CBS microelectronics program is broad. addition to computer memories, work has progressed microminiaturized computer components and in many pes of microcircuits. Inverter circuits, for example, have ready been delivered to systems makers. CBS Elec-

NEW SERVICE NOW AVAILABLE

SEMICONDUCTOR PRODUCTS is making a new source of information available to all firms interested in being kept up to date on materials or equipment for producing semiconductor devices. If you wish to receive all new literature on silicon, germanium, chemicals, machinery, or other such materials, circle #99 on the reader-service card. Your name will be placed on a special list which will be forwarded to all such suppliers. As these suppliers have news available in their field, you'll be notified by them immediately. This service is restricted to firms manufacturing semiconductor devices or firms contemplating entering into production within 120 days.

tronics fabricates both the active components (transistor and diodes) and passive components (resistors an capacitors) which are the integral elements of micro electronic units. Pictured below is a thin-film memory part of the microelectronics program.



The Lansdale Division of Philco Corporation announce the recent development of germanium Micro Allo Diffused-base Transistors (*madt*) having cadmium elec trodes and featuring high speed and high power dis sipation. Designed in response to industry's demand fo high current, high power, high frequency switchin performance, the new *madt* devices have application which primarily include incorporation into data process ing systems (memory drivers, transmission line drivers) oscillators and communications equipment. The extremel low thermal resistance inherent in cadmium gives thes units excellent heat dissipation characteristics obviat ing excessive heating of transistor junctions and thu providing longer life performance. These devices operat at extremely high frequencies as oscillators and amplifier in the *vhf* and part of the *uhf* range. In computer these transistors act as super-high speed switches. The achieve their high frequency performance through built-in electric field, which speeds current carriers fror emitter to collector. Electrochemical processing technique developed by Philco have provided outstanding produc uniformity in the manufacture of these reliable hig frequency transistors.

A new germanium mesa transistor which operates i the low microwave frequency region and a very wid band amplifier employing this transistor have recentl been developed at Bell Telephone Laboratories. In orde to achieve such high frequency operation, the dimension of the new transistor have been cut down so that th total area of the active region is less than the cross section of a human hair. The amplifier employs transmis sion line construction, consistent with the transisto encapsulation.

The device is a diffused-base, alloyed-emitter, PN mesa transistor, designed for application as an oscillato at 3 kmc, or as an amplifier at 1 kmc and below. Th mesa is only 1.8 mils (thousandth of an inch) long, an 1.5 mils wide. Three metal stripes, each 3/10 mils wid by 1-1/2 mils long, are evaporated onto the surface of th tiny plateau and alloyed into the semiconductor. Gol wires 2/10 of a mil in diameter are used for making con nections. The diffused base of the transistor is only 1/5 mil thick. The amplifiers have shown excellent stabilit and the noise figure measured at 200 mc is 5.5 db wit the feedback loops open.

New Products
(from page 71)

Silicon Varactors

Three miniature silicon "pill" varactors have been introduced by Microwave Associates, Inc. intended for use in parametric amplifiers in which variations in stray susceptance effects must be kept to a minimum. Other applications for these diodes include stripline circuits, modulators for frequency synthesis, harmonic generation at the higher microwave frequencies and sub-harmonic oscillators for microwave computers. Overall dimensions are 1/8″ maximum length by 1/8″ maximum diameter. The package shunt capacitance is approximately 0.2 $\mu\mu$f. Series lead inductance is on the order of 10^{-9} henries.

Circle 132 on Reader Service Card

Power Supply

A five ampere transistorized power supply which regulates for constant current is announced by Industrial Measurments Laboratory. Designated Model PCR-101, the supply has been developed especially for laboratory use in connection with battery development and electro-deposition. Its constant current characteristic also makes it highly suited to laboratories concerned with lamp and filament development, thermistors, diodes, meter calibration, low resistance measurement, and magnetic devices.

Circle 112 on Reader Service Card

"Electronic-Grade" Solvents

For the electronics industry, where ultra-high purity solvents are required in the processing of delicate parts, the Fisher Chemical Manufacturing Division has developed 3 solvents: "Electronic-Grade" Acetone, Trichloroethylene and Methyl Alcohol. Each is individually lot-analyzed (including conductivity test), and is ready to use as a bath to remove water, grease, grit and other materials without leaving contaminants behind.

Circle 123 on Reader Service Card

Acid Bright Gold

Technic, Inc. announced the development of Orotherm HT, a 24Kt Acid Bright Gold, which is an entirely new gold complex offering many new application possibilities, especially where heat resistance is specified. Some of its features are: Heat resistance 400°C—5 hours minimum, no strike solution required, 24Kt deposit—not an alloy, greater wear resistance, greater electrical conductivity, wide current density range 1-20 ASF, increased hardness —150 +Knoop, wide temperature range 60° —115° F, exceptional throwing and covering power.

Circle 131 on Reader Service Card

Constant Current Power Supply

John Fluke Mfg Co., Model 351A rack mounting Power Supply is a general purpose precision laboratory instrument with a wide range of applications including the calibration and testing of instruments, meters, semiconductors, torque motors, bolometers and other constant current applications. It also is an invaluable aid to the development of transistor and magnetic circuitry. Model 351A is adjustable in one microampere increments and provides regulation to better than 0.01% with an output of 0 to 100 ma at a maximum of 100 volts.

Circle 103 on Reader Service Card

Diode Test Set

A new instrument, capable of generating and displaying the millimicrosecond recovery characteristics of ultra fast switching diodes on conventional oscilloscopes, has been announced by Lumatron Electronics, Inc. Model 510 includes a test fixture for rapid, manual insertion of coaxial lead diodes, a metered regulated power supply, a mercury switching type pulse generator, a wide band delay unit and a millimicrosecond sampling converter. The fixture has a coaxial structure and includes all necessary components to display the recovery characteristics of extremely fast diodes.

Circle 117 on Reader Service Card

Measuring Equipment

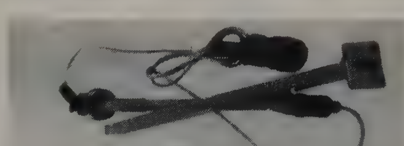
New Semiconductor Lifetime Measuring Equipment in a single package with improved versatility, operating convenience and higher sensitivity is announced by Electro Impulse Laboratory. Lifetimes from 1 microsecond up are measured. The equipment is fully sheilded with extraneous noise eliminated and is completely self-contained. The only additional equipment required is a good scope. Simple operation and fast results. Exceptionally suitable for production testing of semiconductor materials.

Circle 119 on Reader Service Card

Noise Diode Tube Mount

A new tube mount manufactured by DeMornay-Bonardi provides a convenient means for coupling a gas diode noise source to a standard-size waveguide. The gas diodes are sources of random noise for use in measuring the overall noise figure of microwave receivers. Unit is used with standard tubes. Mis-match will not exceed 1.15 VSWR, thus insuring practically perfect energy transfer from gas plasma to waveguide output. Noise output is 16 db for all sizes.

Circle 104 on Reader Service Card



Telephone Battery Chargers

A line of silicon-rectifier chargers has been developed by Exide Industrial Division of The Electric Storage Battery Company. These Telephone Rectifiers (TR's) convert alternating current to the direct current required for battery charging. They are controlled by highly reliable magnetic amplifiers which, with voltage reference and sensing circuits, automatically maintain proper floating or equalizing voltages at the battery terminals. Voltage regulation within plus-or-minus one percent extends over the complete range, from zero to full load.

Circle 121 on Reader Service Card

Automatic Transistor Test Set

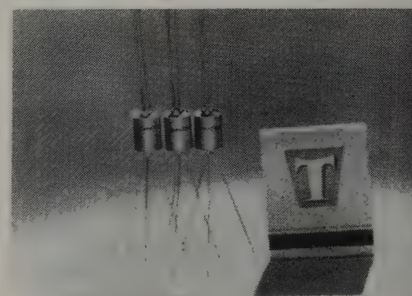
Designers for Industry, Inc., has designed a set to automatically test transistors. The test set will convey transistors at a maximum rate of 2400 units per hour through a line of 14 test stations. A series of up to 38 tests are performed, including tests for orientation, short circuits, 15 *d-c* tests and 21 *a-c* tests. Loading of transistors on the chain is done manually. All other operations are automatic. Four types of environmental units can be supplied. One raises the temperature to 85°C by controlled air heating. A refrigeration unit lowers temperature down to −55°C.

Circle 125 on Reader Service Card

Transistor Pulse Transformers

The development of the Type BME series of hermetically-sealed subminiature low power pulse transformers for use with transistorized blocking oscillator and interstage coupling circuits, has been announced by Technitrol Engineering Company. Units are available in a range of pulse widths from 0.05 to 5.0 usec at repetition rates up to 10 mc and in three grades: Commercial Grade, operating at temperatures from −25°C to +105°C; MIL Grade, operating from −55°C to +105°C meeting Grade 5, Class R requirements of MIL-T-27A and MIL-T-21038; and X-Grade, which meets all MIL Grade requirements and has an increased temperature specification to +150°C.

Circle 128 on Reader Service Card



Power Supply

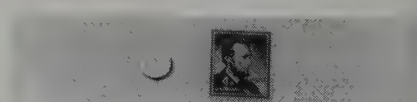
Matthew Laboratories introduces its Model UCS-200 Bantam Size Constant Current Regulated Power Supply designed for the powering of solid state equipment on the bench or in the rack. Transistor and zener diode regulated, it measures only 4.75″ wide by 4.5″ high by 6.25″ deep while providing up to 400 milliamperes at a maximum of 30 volts. Regulation is better than 1% against line and no load to full load variations. Ripple is less than 5 Mv.

Circle 105 on Reader Service Card

Disc Thermistor

The VECO 34D4 disc thermistor is now available for the first time as a stock item from Victory Engrg. Corp. Previously made only to order, its resistance is matched to a nominal resistance versus temperature curve within ±5%. The built-in accuracy and reliability make it ideally suited for temperature compensation or temperature measurement. ment.

Circle 129 on Reader Service Card



New Literature

A technical data sheet describing the hysical properties of partially coated netals used as base tabs in the manuacture of transistors, or as a solderoated part acting as its own preform, s now available from Alpha Metals, Inc. ncluded in this data sheet is a descripion of the metals and alloys that can e coated through this new Alpha procss and the physical properties of the lloy-coated metals. The dimensional ange of base materials and full or parial coatings are listed.

Circle 161 on Reader Service Card

Publication of a semiconductor engieering guide keyed to the needs of both he engineer and the purchasing agent as recently been announced by the ndustrial and Government Division of Radio Shack Corp. The book includes wo listings of the semiconductors of nine nanufacturers: in sequence by parameter nd function, and a list by transistor and iode type number. An additional innovaion is the section of dimensioned mountng diagrams.

Circle 162 on Reader Service Card

Lindberg Engineering Company announces the availability of Bulletin No. 081. This new literature describes and llustrates a line of gaseous and solid iffusion furnaces for the manufacturer f transistors and semiconductor devices. The bulletin includes a chart of technical pecifications of the single zone, two zone nd multi-zone types as well as illustraions and technical application data on everal of the Lindberg diffusion furaces.

Circle 163 on Reader Service Card

A new 24 page catalog covering its line f sub and micro-miniature hermetically ealed relays has been made available by Filtors, Inc. Designated as catalog numer four, the multi-colored book includes omplete specifications on the firm's "Powrmite" series micro-miniature reays and its numerous sub-miniature ypes. The catalog includes information n mounting styles, available terminal ypes, sockets, ordering data, and dry ircuit information.

Circle 164 on Reader Service Card

A new 6-page bulletin on Ledex hernetically-sealed stepping and selector witches that are stocked for immediate elivery has been published by G. H. Leland, Inc. The bulletin (D-1059) supplies complete physical, performance and nvironmental data. It also contains hotographs and line drawing of all modls—ranging from a 2-pole, 2-position tepper weighing less than 12 oz. to a 4-pole, 2-throw unit that weighs only lbs. 4 oz.

Circle 165 on Reader Service Card

Marshall Products Company has issued specification sheet on the new 58-HD acuum hot hardness testing furnace that ncludes complete engineering data on construction and performance. Introduced earlier this year, the 58-HD furnace was designed for hardness tests on metals at temperatures up to 3000°F. in a vacuum range of $1X10^{-4}$ mm mercury.

Circle 166 on Reader Service Card

Newly-formed Electronic Transistors Corp. has issued Availability Catalog #AO-1 of Germanium Transistors (for interchangeability). The company's line of 412 different germanium types will include switching, computing, entertainment and industrial transistors. Folder lists type numbers, description and applications.

Circle 167 on Reader Service Card

Victory Electronics, Inc. has issued a catalog sheet on their Victory Variant space saver power supply. Illustrates uses, models available, physical sizes, other specifications.

Circle 168 on Reader Service Card

Jones & Lamson Machine Company has issued Catalog 5700 giving complete information on their Optical Comparator and Universal Measuring Machine. Contains applications, operation, models, features and specifications, standard charts, standard fixtures, special charts and fixtures, accessories, lens data, model specifications.

Circle 169 on Reader Service Card

Monsanto Chemical Company's Inorganic Chemicals Division has announced the publication of a new technical bulletin on Santocel A, a silica aerogel used for thermal insulation. The bulletin contains product descriptions covering chemical, physical and structural properties, in addition to shipping and handling notes and suggestions as to use.

Circle 156 on Reader Service Card

New paper, 6 pages describing metallurgical properties, operational data, and uses of a patented acid-type industrial gold electroplating formulation, trademarked Autronex, is offered by Sel-Rex Corporation. The technical exposition covers in detail the composition of this low pH gold formulation for industrial applications. Deposit characteristics, corrosion resistance, equipment requirements, solution makeup and maintenance, gold consumption, trouble shooting, analytical procedures, metal content chart are carefully outlined.

Circle 152 on Reader Service Card

Full-color sheet gives complete information on new color range in flexible insulators for Mueller Clips, created for quick, easy and positive identification of clip-equipped electric leads. Sheet sets forth many advantages in testing, identification, and product appeal gained by fuller use of the new color range.

Circle 153 on Reader Service Card

Flexible silicon power rectifiers, which can be built to supply virtually any desired voltages and currents, are described in a new bulletin published by I-T-E Circuit Breaker Company. The eight-page, two-color illustrated bulletin furnishes information to aid engineers, consultants and scientists in such fields as electrochemical, industrial and research. The bulletin describes such features as space-saving, high reliability and efficiency, and low maintenances.

Circle 154 on Reader Service Card

Personnel Notes

(from page 20)

Dr. Arthur Bramley, well known solid state physicist, has joined the electronics section of Republic Aviation Corporation's scientific research staff, it was announced recently. Dr. Bramley is a Fellow of the American Physical Society and the American Association for the Advancement of Science. He is a member of the Institute of Radio Engineers and the American Chemical Society. During his career he has obtained nine patents, dealing principally with electroluminescent displays, solid state diode fabrications and isotope separation. At Republic Dr. Bramley is engaged in a program of solid state research.

A major expansion of the Research and Development Department of General Instrument Corporation's Semiconductor Division, involving addition of key scientific and engineering personnel and tripling of laboratory space at the Division's Newark, N.J., facility, is announced by Maurice Friedman, Vice President and General Manager of the Semiconductor Division. Dr. Frank S. Stein, formerly Manager of Device Development at Westinghouse Electric Corporation's Semiconductor Department, has joined General Instrument as Manager of the Semiconductor Research and Development Department, under over-all direction of Mr. Friedman.

Appointment of William R. Meoli as Vice President and Sales Manager of Veeco Vacuum Corporation was announced recently. Mr. Meoli joined the company in 1955 and has served as Chicago regional sales manager, and assistant sales manager. He is a graduate of Polytechnic Institute of Brooklyn and received a Bachelor of Science degree in Electrical Engineering. He is a member of the American Vacuum Society.

David J. Hall has joined the Electronic Chemicals Division of Merck & Co., Inc. as a sales engineer. He will be concerned with the sale of silicon for use in electronic devices and will cover the metropolitan New York area and the mid-west. Mr. Hall brings to Merck a varied experience as an engineer, consultant and sales engineer in the electrical, electronic and instrumentation fields, encompassing 18 years.

Jon H. Myer has been appointed manager of the newly-created materials development and supply laboratory of Hughes Aircraft Company's semiconductor division, it was announced by Dr. Richard A. Gudmundsen, manager of the division's research and development laboratories. The new lab will develop and supply new semiconductor materials to be used in the production of subminiature diodes, transistors and rectifiers, Dr. Gudmundsen said. Mr. Myer, who joined the Hughes semiconductor division in 1953, has been head of the technical services department.

The appointment of Dean M. Unger as product line manager, germanium mesa transistors for the Semiconductor Division of Sylvania Electric Products Inc. has been announced by Elmer J. Perry, divisional manufacturing manager. Mr. Unger, who has been manager of device engineering for the division since 1958, joined Sylvania in 1953 as a physicist at Ipswich, Mass.

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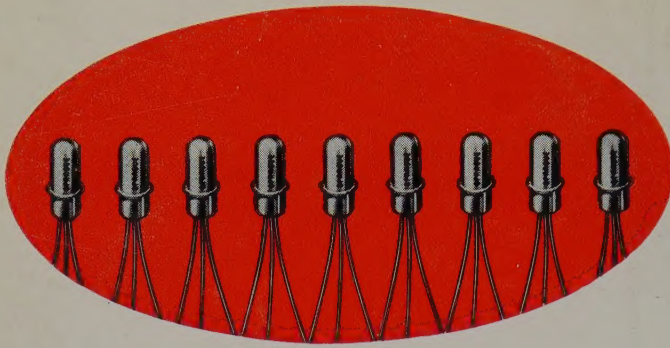
(Continued)

new transistors from Sprague*



SUPER HIGH-SPEED SWITCHING TRANSISTORS TYPE 2N501

	Typical	Maximum	Units
Rise Time (t_r)	9	18	mμsec
Storage Time (t_s)	9	12	mμsec
Fall Time (t_f)	7	10	mμsec

In circuit with current gain of 10 and voltage turnoff.

Also available as special type 2N501A for 100° C. maximum storage and junction temperatures.

This table tells the story. Sprague Type 2N501 germanium micro-alloy diffused-base transistors are the fastest mass-produced transistors available anywhere! They are unexcelled for high-speed computer applications. The ultra-low rise, storage, and fall time cannot be matched by any other transistor.

Ultra-precise process control in manufacture results in superb and consistent high quality. The basic electrochemical process of fabrication takes the guesswork out of transistor manufacturing. The result is outstanding uniformity of product.

Because of the electrochemical process, Sprague is able to fabricate a graded-base transistor with no intrinsic base region. The Type 2N501 can thus maintain its super high-speed switching characteristics right down to its saturation voltage, providing all the advantages of direct-coupled circuitry with no impairment of switching speeds.

Type 2N501 Transistors are available from Sprague now at extremely reasonable prices. They are transistors you can use today! You need not delay your development work for the future when you design high-speed switching circuits with Type 2N501 Micro-Alloy Diffused-Base Transistors.

Write for complete engineering data sheet to the Technical Literature Section, Sprague Electric Company, 467 Marshall Street, North Adams, Massachusetts.

* *Sprague micro-alloy, micro-alloy diffused-base, and surface barrier transistors are fully licensed under Philco patents. All Sprague and Philco transistors having the same type numbers are manufactured to the same specifications and are fully interchangeable.*

SPRAGUE COMPONENTS:

TRANSISTORS • CAPACITORS • RESISTORS
MAGNETIC COMPONENTS • INTERFERENCE FILTERS
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